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CONTENTS

Society and Related Activities

	Page
National Metal Exposition	2
Fall Meeting Program	2
Miller Medal Award	2
Obituary	2
Section Activities	3
Employment Service Bulletin	3

Technical Papers, Items and Reports

Erecting Steel Buildings and Strengthening Steel Bridges by Welding, by Frank P. McKibben	4
Must Industry Be a Pawn or a Power? by Charles F. Abbott	15
Some Factors Governing the Choice of Welding Electrodes, by Wayne A. Howard	19
Discussion of Paper by Frank B. Walker on "Visual Inspection of Metal Arc Welds," by Anthony S. Coombs	21
Structural Changes at Stress-Relieving Temperatures, by H. R. Bullock	22
Spherical Tank Built by Arc Welding, by A. F. Davis	24
Cromansil Steels, by Richard Tull	24
Standard Specifications for Resistance Welding Transformers	25

Departments

Safety Kinks	
Safe Handling of Oxygen and Acetylene Cylinders, by T. C. Fetherston	23
Current Welding Literature	26

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SOCIETY AND RELATED ACTIVITIES

National Metal Exposition

Mr. Eisenman has announced that the plans for the floor space for the 1933 Metal Congress Exposition to be held in Detroit, October 2–6 are now available. Exhibitors in the welding field are urged to make their reservations for space at once in order to get preference as to desirable location. For exhibit space communicate with W. H. Eisenman, Director, National Metal Exposition, 7016 Euclid Avenue, Cleveland, Ohio.

Fall Meeting Program

The Meetings and Papers Committee are now at work on the Fall Meeting program and have provided some very unusual sessions including a series of reports on fundamental research, applications of welding to structural steel, ships and pipes. A whole session is to be devoted to the welding of corrosion resisting metal and another to important resistance welding applications. Inasmuch as the Fall Meeting will be held in Detroit, the center of the automotive industry, several important papers covering applications in this field have been provided and arrangements are being made for interesting inspection trips. Further announcements will be made in later issues of the Journal.

Herbert H. Moss Receives Miller Medal

Herbert H. Moss was born in 1889, in Cleveland, Ohio. His father was a building contractor and his early contacts with the practical and administrative phases of construction work led to an interest in architecture. He studied architectural motifs in Cincinnati and New York and supplemented this with two years of technical training at Baltimore Polytechnic Institute. He was awarded the O'Rourke prize in architecture for work done at Cooper Union.

In 1913 he was employed by the General Electric Company in the Building and Equipment Department, Lamp Division, where he specialized in the design of reinforced concrete structures and attained the position of assistant chief draftsman.

At the outbreak of the World War, Mr. Moss decided to enter the field of munitions plant construction and was with Aetna Explosives Company, in charge of the Estimating and Appropriation Department, and later as general supervising field engineer of construction for the High Explosives Division.

In 1918 he became a staff executive of the Everyly M. Davis Chemical Corporation, where he served successively as: supervisor of purchases and traffic over construction activities at the Government Picric Acid Plant, Little Rock, Ark.; resident engineer in the rehabilitation of the Rainy River Plant of the Western Canada Pulp and Paper Company in British Columbia; and manager of the industrial department of the Nashville Industrial Corporation.

Herbert H. Moss

Returning to New York in the fall of 1923, he became interested in the growing possibilities of oxyacetylene welding as a general construction tool and as a result became associated with The Linde Air Products Company. After a course of practical training in welding, cutting and layout, he was assigned to a natural gas transmission project in eastern Texas to aid in the construction of two 5000-hp. gas booster stations, giving particular attention to the welded piping. This assignment provided an opportunity for introducing into the welded piping field the practices of shop pre-fabrication common to many fields of construction. Shop fabrication of welded headers, traps and control equipment resulted in greater speed and economy of installation.

Mr. Moss next investigated structural welding, making a series of conversion studies of mill-building frames which led to the development of a means for butt welding tubes and structural shapes through the medium of "insert plates," for which four United States patents were allowed in 1930. These studies were confirmed by an elaborate series of tests of 40-ft. oxyacetylene welded trusses in Buffalo in 1926.

Continuing his contributions to structural welding, Mr. Moss aided in the design and construction of the 300-ton oxyacetylene-welded mill type building erected in the plant of the Union Carbide Company at Niagara Falls in 1929. This was the first large all gas-welded building.

During the past several years, as a member of the Development Section, Engineering Department, of The Linde Air Products Company, Mr. Moss has devoted a major portion of his time to problems concerning the applications of welding and cutting for buildings and equipment structures, and transportation equipment, particularly freight cars and shipping containers. During 1930 he aided in the design and development of a series of 70-ton hopper type coal cars built for the Chicago Great Western Railroad by The Pullman Car and Manufacturing Corporation.

In 1931 his aid to the Committee on Technological Developments under President Hoover's Conference on Home Building and Home Ownership in connection with the use of welding in present and future small house construction, culminated in a presentation of the subject before the Conference. More recently, Mr. Moss has given careful study to advanced developments in oxyacetylene cutting, particularly precision cutting and flame machining, the preliminary results of which were presented in a paper read before the AMERICAN WELDING SOCIETY at its 1932 Fall Convention.

During the past five years Mr. Moss has aided a number of committees and sub-committees of the AMERICAN WELDING SOCIETY, American Bureau of Welding, International Acetylene Association and the Bureau of Standards in the codification and standardization of numerous practices for experimental and applied welding, largely for building and aircraft purposes. In 1932 he served as Chairman of the Oxyacetylene Committee of the International Acetylene Association. Mr. Moss is at present serving on various important A. W. S. Committees: Vice-Chairman, New York Section; Chairman, Committee on Building Codes; member of Steering Committee of the Structural Steel Welding Committee under American Bureau of Welding; member of Committee on Nomenclature, Definitions and Symbols.

Mr. Moss is an associate member of the American Society of Mechanical Engineers and a member of the AMERICAN WELDING SOCIETY and the International Acetylene Association. He is married and lives in Brooklyn, N. Y.

EDITOR'S NOTE: Since the award of the Miller Medal, Mr. Moss was elected chairman of the New York Section, A. W. S.

Obituary

Mr. J. B. Green, Vice-Chairman of the Chicago Section and President of the Fusion Welding Corporation, died in St. Luke's Hospital, Chicago, on Monday morning, April 24th.

SECTION ACTIVITIES

BOSTON

At the 1933 Annual Meeting of the Boston Section the following officers were elected:

Chairman, L. F. Jackson, The Linde Air Products Co.

Vice-Chairman, A. S. Coombs, Whitney Engineering Co.

Secretary-Treasurer, H. D. Large, Navy Yard, Boston.

Directors, Carlos Krebs, General Welding & Equipment Co.; J. N. Harkins, Air Reduction Sales Co.; C. W. Babcock, Westinghouse Elec. & Mfg. Co.; H. P. Peabody, J. A. Roebling's Sons Co.; H. N. Ewertz, Austin-Hastings Co.; J. A. Potter, Navy Yard, Boston; F. O'Rourke, Massachusetts Welding Co.

Section Representative on Board of Directors, H. P. Peabody, J. A. Roebling's Sons Co.

CHICAGO

At a meeting of the Chicago Section held on April 21st, Mr. E. Wanamaker of the C. R. I. & P. Railroad presented a paper on "Railroad Welding Yesterday and Today," which dealt with maintenance welding of rolling stock and track.

This paper was followed by a talk on "Metal Spraying," by K. D. Falk, who has had six years of practical experience in the field of metal spraying. Demonstration of metal spraying of several metals, including bronze and iron, was shown.

The May meeting of this Section was held on the 19th at the Congress Hotel. "The A. S. M. E. Code as It Affects Pressure Vessel Welding" was the subject of the meeting. The speakers included: Prof. C. A. Adams, Harvard University, who outlined the purpose of the meeting. Mr. E. R. Fish, Hartford Steam Boiler Inspection and Insurance Company, presented an outline of the origin and functioning of the Boiler Code Committee, dealing particularly with the developments of welding rules. Dr. H. H. Lester of Watertown Arsenal, presented an interesting summary of the use of X-rays for inspecting welded structures under his supervision at the Watertown Arsenal. Mr. T. McLean Jasper, A. O. Smith Corp., followed with a talk on the purposes and effects of stress-relieving in connection with heavy pressure vessel welding. Other speakers included Mr. J. C. Hodge of the Babcock & Wilcox Company, Mr. E. B. McGuire, Manager, Hamler Boiler & Tank Company, Mr. Robert Kinkead, Cleveland, and Prof. Huntley of Armour Institute of Technology.

The following officers and directors of the Chicago Section have been elected for the coming year:

Chairman, E. Wanamaker, Chicago, Rock Island and Pacific Railway Co.

Vice-Chairman, D. C. Wright, Graver Tank & Mfg. Corp.

Secretary-Treasurer, K. B. Mackenzie, *The Welding Engineer*.

Directors for three years, H. O. T. Ridlon, Barrett Hardware Co.; Jules Muller, Hollup Corp.; C. D. Young, Metal & Thermit Corp.; A. L. Wilson, Miss. Valley Structural Steel Co.

DETROIT

The following officers of the Detroit Section were elected to serve for the term of 1933–1934:

Chairman, M. P. Bailey, The Detroit Edison Co.

Vice-Chairman, R. P. Bailey, General Electric Co.

Secretary-Treasurer, W. M. Hayes, Air Reduction Sales Co.

Executive Committee, Commercial, H. W. Roth, Controloweld Corp.

Executive Committee, W. H. Zorn, Detroit Edison Co.

LOS ANGELES

The April meeting was held on the 20th. Thirty-four members and guests were present. Mr. Roy Thomas outlined a plan he has developed and which he calls his "Welder's Clearing House." Mr. Thomas personally proposed to finance this project and calls upon all employers for their consideration. It is his plan to qualify and classify every welder, according to his particular fitness and to place him only on jobs where the welder is qualified to do good work.

Mr. T. C. Smith reported on progress of A. S. M. E. Code.

Mr. W. D. Cleghorn, Sales Engineer, Mohr Manufacturing Company, Minneapolis, read a paper by their Mr. C. F. Olmstead on "Welded Pressure Vessels and Furnaces for Strain Relief." Following this, Mr. Bennett S. Chapple, Jr., Insulated Steel Homes, Cleveland, gave his paper, "Frameless Steel Homes." Both papers were well worth while.

A joint meeting of the Los Angeles Section was held with the American Society for Steel Treating on Thursday, May 18th. A 3000-ft. motion picture film which was awarded first prize by the American Association of Amateur Cinematographers was shown through the courtesy of Bausch & Lomb Optical Co. of California. The film was "The Eyes of Science." Mr. George Rhode, B. & L. Representative, described the picture and answered questions after the showing of the film. Mr. J. W. Capek, Industrial X-Ray Corp., Los Angeles, presented a paper on "X-Ray in the Field of Welding." In addition to slides, photographs and motion pictures, there was also on display an actual demonstration of one of their portable X-ray units.

PHILADELPHIA

Regular monthly meeting of this Section was held on April 17th. Lieutenant Commander A. I. McKee, U. S. N., spoke on "Influence of Welding on Ship Construction."

There were 65 present at the May 15th meeting to hear Mr. Richard L. Binder of the Metal Coating Company of America talk on "Metal Coating." Mr. Binder also had with him a very interesting exhibit showing the various applications to which his Metalayer has been put.

The next meeting of this Section will be held in September.

At the Annual Meeting on April 17th the following officers were elected:

Chairman, Charles M. Rusk, R. D. Thomas & Co.

Vice-Chairman, A. G. Desch, Oxweld Acetylene Co.

Treasurer, R. D. Thomas, R. D. Thomas & Co.

Secretary, H. E. Hopkins, R. D. Thomas & Co.

PITTSBURGH

At the April 12th meeting Mr. H. J. Bartlett, Specialty Sales Dept., Crane Company, presented a paper on "The

(*Continued on page 18*)

SERVICES AVAILABLE

A-16. Electric Welder. Considered a first class operator. Thirteen years' experience both at home and abroad of which ten years have been spent as foreman and instructor. Passed tests for Class II, A. S. M. E. Code for Unfired Pressure Vessels. Excellent references.

A-190. Welder experienced in electric and acetylene welding on all kinds of work. Last ten years with Westinghouse Elec. & Mfg. Co., two years as group leader of welders with this company. Some experience on inspection of welds. Hand and automatic welding.

A-195. Welding engineer desires position. Passed State Civil Service Examination for Director of Standards and Director of Purchases. Formerly purchasing agent, assistant chief engineer, sales engineer, of the International Oxygen Company; general manager of Goldy Electric Co. and Goldy Electric Corp.; sales engineer of General Electric Co.; instructor of purchasing of University of the State of New York.

A-196. Graduate C.E. Four months with General Electric as welding operator and designer of welded structures. Experienced draftsman.

A-197. Experienced electric and acetylene welder desires position.

A-198. Welding engineer desires position. Research and development engineer for eight years with Western Electric Company. Specialist on coated rod welding and experienced with all forms of arc, spot, resistance, flash welding and gas cutting and welding. Have conducted extensive physical, chemical, radiographic and metallographic studies on numerous weld specimens. Have B.S. and M.E. degree in engineering and a wide practical experience in a diversified line of manufacturing.

Erecting Steel Buildings and Strengthening Steel Bridges by Welding

By FRANK P. McKIBBEN

†A lecture presented at the Annual Meeting, American Welding Society, April 27–28, 1933, by Frank P. McKibben, Consulting Engineer. Part I published in May issue, Journal A. W. S.

PART II

Strengthening Wrought Iron and Steel Bridges by Welding

Why Do Metallic Highway Bridges Need Strengthening or Renewal?

When wrought iron or steel highway bridges become unsuitable for properly performing their functions, either repairs or complete renewal are necessary. Until recently the temptation was accepted too readily to replace old bridges with entirely new construction when often considerable remaining value in the old structures could be saved by repairs. Under present conditions, however, the tendency is to exhaust every possibility of repairing before decision is reached to build anew.

Metallic bridges must be repaired or renewed, because of (*a*) corrosion, (*b*) cracked parts, (*c*) increased live loads and (*d*) inactive members.

(*a*) Corrosion is a great lover of steel. It is less intimate with wrought iron. When corrosion attacks steel fiercely, as on top flanges of I-beam stringers for example, oxide forms in layers which separate easily from the main unrusted steel. But when wrought iron corrodes, small globular particles of oxide form, which also may be readily removed. The action on steel is much more rapid, more severe, than on iron. Of course, paint will prevent this, but this precaution is often neglected. An old bridge, recently removed to make way for a much larger structure, had some wrought iron trusses erected in 1872, and other steel trusses of 1902 vintage. The iron was in excellent condition, while the steel was badly corroded when the structure was replaced in 1929.

Atmospheric agencies cause metal to corrode, but in ordinary highway bridges the parts where the action is most severe are those close to or in contact with earth, as column footings, girder or truss bearings or piers or abutments; top flanges of stringers or floor beams supporting plank floors; girder webs or truss verticals close to or against the ends of floor planking, Fig. 10; structures subjected to locomotive gases.

Railroad bridges, especially steel floors thereof, are often found corroded by brine from refrigerator cars.

(*b*) Cracks in parts of steel bridges are caused by bending moments inadequately provided for. They occur because of oversight in designing details and are found more frequently in railroad than in highway bridges. Cracking along fillets occurs frequently at junction of vertical and horizontal legs of top flange angles of railway bridge stringers and along fillets in angles connecting stringer and floor beam webs. The former are due to bending in outstanding legs resulting from pressure from

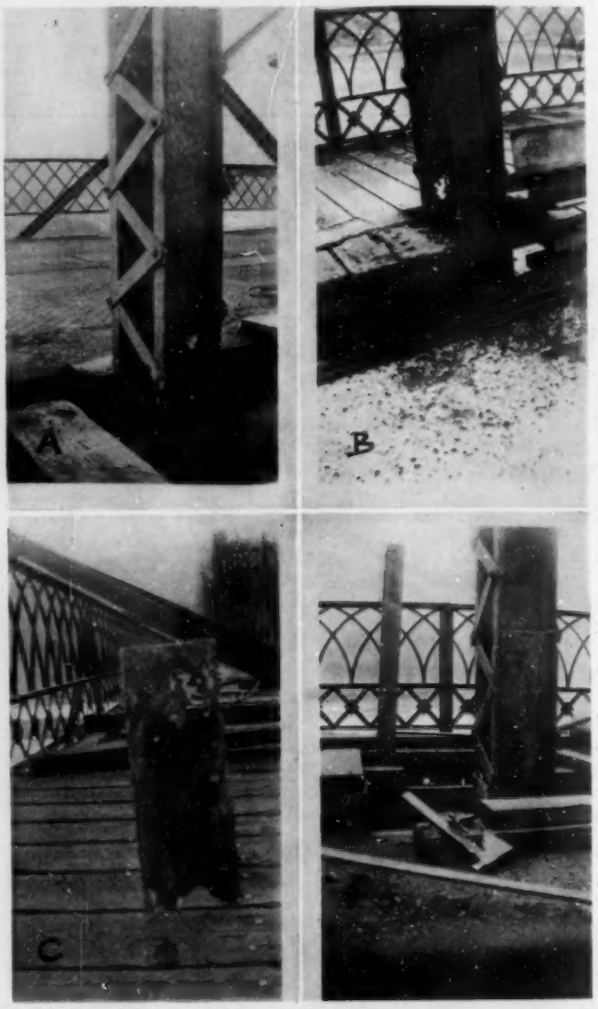


Fig. 10—Venango County Bridge on Eighth Street, Franklin, Pa. Repaired by Welding by Pennsylvania Department of Highways. (*A*) Typical Channel Post with Hole Corroded in Web before Repairing. (*B*) Opposite Side of Post Shown in *A* before Repairing. (*C*) Section of Corroded Channel Post after Removal. (*D*) Channel Post with Welded Plate after Repairing

ties, the latter from bending caused by partial fixity of stringer ends.

(*c*) Metallic bridge floors designed for five-ton wagons in 1885 clearly have reasons for resenting the passage now of motor trucks weighing 15 tons. When we designed the Smith Street Bridge (Bausch Memorial) in 1928, in Rochester, N. Y., we found trucks operating in Rochester having the following characteristics: wheelbase 13 ft. 3 in.; center to center of rear wheels 6 ft. 0 in.; tread 7 ft. 2 in.; light weight 14,200 lb.; maximum loaded weight 38,200 lb., with three-fourths or 28,650 lb. on the two rear wheels. The old bridge was not only highly overloaded but, having a roadway width of only 21 ft., was also inadequate for modern traffic. This was a case for replacement, not for repair. Thirty-ton trucks were used in designing stringers and floor beams of the new bridge.

The American Association of State Highway Officials in convention, November 17, 1932, recommended for adoption by all States, the following limitations for axle loads and gross weights of vehicles:

"*Axle Load.*—(*a*) The wheels of all vehicles, including trailers, except those operated at 10 miles per hour or less, shall be equipped with pneumatic tires.

"(*b*) No wheel equipped with high pressure, pneumatic, solid rubber or cushion tires shall carry a load in excess of 8000 lb., or any axle load in excess of 16,000 lb.

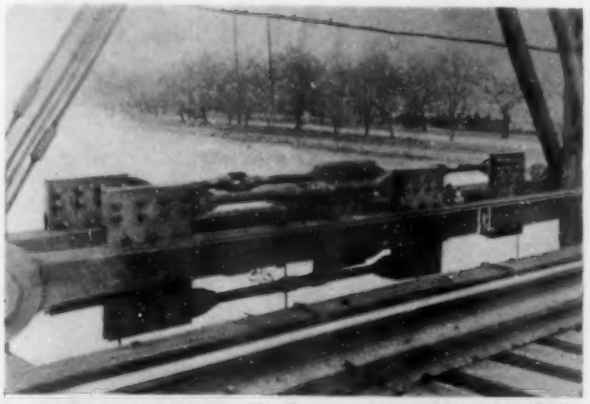


Fig. 11—Shortening Inactive Eye-Bars on Lower Chord by Welding Long Bridge over Potomac River, Washington, D. C. Temporary Turnbuckle Units on Three Eye-Bars of an Eight-Bar Lower Chord. December 19, 1931

"Research indicates that low pressure pneumatic tires can carry 9000 lb. per wheel without increasing pavement slab stresses.

"An axle load shall be defined as the total load on all wheels whose centers may be included between two parallel transverse vertical planes 40 in. apart.

"(*c*) These limitations are recommended for all main rural and intercity roads, but should not be construed as inhibiting heavier axle loads in metropolitan areas if any State desires.

"(*d*) These weight specifications for wheel and axle loads may be restricted by the State Highway Department for a reasonable period where road subgrades are materially weakened from thawing after deep frost, or from a continued saturated condition of the soil."

"*Gross Weights*.—Subject to the limitation imposed by the recommended axle loads, no vehicle shall be operated whose total gross weight, with load, exceeds that given by the formula $W = c(L \text{ plus } 40)$ where:

W = total gross weight, with load, in lb.;
c = coefficient to be determined by the individual States;
L = the distance between the first and last axles of a vehicle or combination of vehicles in feet.

"A value of 700 is recommended for c as the lowest which should be imposed, but this should not be construed as inhibiting greater values.

"NOTE: This gross weight recommendation is particularly applicable to bridges, since axle loads and length limitations are determinative in their practical application."

In applying the above suggestions, it should be remembered that heavier loads than those given may be specified by the States for metropolitan areas.

(*d*) The fourth group of possible causes to necessitate bridge repairs, namely, inactive members, consists almost exclusively of inactive eye-bars, caused by wearing at pins, or from deflection of floor beams. The defect manifests itself in the elongation of one of a pair of eye-bars to such an extent as to render it idle, thus throwing all stress on the other. In highway bridges, this is frequently found in vertical suspender, diagonals and tension chords of trusses. In railroad bridges, this is also true. In fact, most of the pin-connected trusses in which inactive eye-bars have been shortened, by riveting or by welding, have been in railroad bridges. In one railroad bridge, 104 eye-bars were thus treated, Fig. 11.

The process consists of welding an adjustable yoke to the inactive bar, stressing the bar by means of the adjustments, then cutting out a portion of the bar with an oxyacetylene torch. Extensometers should be used to determine the amount of shortening necessary to render equal the unit dead-load stresses in the two eye-bars. Starting with zero stress, the amount of shortening required to accomplish this is SL/AE, where S is total stress in the two eye-bars; A, their combined cross-sectional areas; L, gage length in inches; E, modulus of elasticity. Thus, if the desired unit stress in each bar is 5000 lb./sq. in., after adjustment is made in one of them, L is 10 in., E is 30,000,000; the shortening of a 10-in. gage length is 1/600 in. If the unit stress is 10,000 lb./sq. in., the shortening is 1/300 in.

Another illustration of this transference of a part of the dead load stress from one old piece to a new one, is shown when a new flange plate is added to an existing plate girder flange in such a manner as to render new steel effective in carrying its share of dead as well as live load. The process of accomplishing this consists of clamping the new plate to the old steel; welding these together at one end; heating the new plate to increase its length by a calculated amount; then while heated, the new plate is welded at its free end to the old steel; finally, the new is welded to old steel throughout its length. In cooling, part of the dead load stress is transferred to the new steel.

Patent rights on each of the above-mentioned processes of transferring stress from old to new steel are claimed by some welding companies.

Some Bridges Must Be Replaced

For most cases where strengthening or repairing is desirable, welding is ordinarily the most economical process to apply. Usually the only remedy for inadequacy due to narrow roadways, or approaches unsuitable for fast moving traffic, is replacement of the existing structure. Extreme density of traffic during periods of greatest demand on the structure determines the course of action. If traffic is subjected to serious delays or numerous accidents and the bridge cannot be widened by additions to the existing structure, replacement becomes necessary.

Accompanying Table 5, showing number of vehicles crossing the Genesee River Bridges in Rochester, N. Y., during eleven hours between 8 A.M. and 7 P.M. of one day in April of each year, is interesting as illustrating the growth of traffic over a period of years. But it is not so much the total number of vehicles crossing a bridge in a day that measures the limit of life, as does the maximum number during a period of short duration—an hour for example. Table 6 showing the maximum hourly traffic over Rochester's river bridges is, therefore, of interest in this connection. Clarissa Street and Driving Park Avenue Bridges carried in 1931 practically the same maximum hourly traffic (1644 and 1646) on the day in question; but the former has a 39-ft. and the latter only a 20-ft. driveway, making the density of traffic per lane on Driving Park Avenue Bridge double that of Clarissa Street Bridge. Driving Park Avenue Bridge (built 1890) with its narrow roadway reached its traffic-carrying capacity while Clarissa Street Bridge (built 1918) with wider driveway showed no such congestion. Completion of Ridge Road Bridge in December 1931 greatly relieved its neighbor, Driving Park Avenue Bridge, in 1932.

Tables 5 and 6, reflecting the traffic of one day only, but not necessarily the day of maximum traffic, represent in part the excellent cooperative effort of the Rochester Engineering Society and the Boy Scouts who make an

Table 5—Total Number of All Kinds of Vehicles on Genesee River Bridges, Rochester, N. Y., for One Day 8 A.M. to 7 P.M.

Bridge	1910	1919	1922	1928	1929	1930	1931	1932	Width of Driveway, Ft.
Elmwood	..	..	2110	2993	3594	3607	5077	5095	20.67
Clarissa	1072	..	5263	9625	9314	8250	10,840	11,374	39
Court	3825	7247	8344	7691	8827	10,591	11,338	11,219	40
Broad	..	..	..	11,657	11,847	9786	10,426	10,263	52
Main	6226	9374	8900	11,810	13,376	12,111	13,547	12,941	63
Andrews	2012	2392	..	5611	6713	6215	6666	6271	40
Central	..	..	..	7642	10,331	9351	10,468	11,603	42
Platt	..	..	..	5911	6102	9450[3]	5060[3]	3454	22
Smith	1241	2961	2165	5222	6095	[1]	7324[2]	7983	58
Driving Park	..	2610	..	7789	8848	9385[3]	8571[3]	4221[5]	20
Ridge Road	..	..	..	..	..	..	..	6204[4]	60
Stutson	..	942	..	1054	1193	1190	1539	1208	29
Total	14,376	25,526	26,782	77,005	86,240	79,936	90,856	92,236	

[1] Smith Street Bridge being rebuilt.
[2] New Smith Street Bridge opened for traffic in December 1930.
[3] Influenced by reconstruction of Smith Street Bridge.
[4] Ridge Road Bridge opened for traffic in December 1931.
[5] Influenced by opening of Ridge Road Bridge.

Table 6—Maximum Hourly Traffic over Genesee River Bridges in Rochester, N. Y., Recorded during One Day in April of Each Year

	1928	1929	1930	1931	1932	Width of Driveway, Ft.
Elmwood	465	533	612	751	821	20.67
Clarissa	1477	1519	1467	1644	1574	39
Court	957	1192	1417	1421	1438	40
Broad	1441	1453	1275	1345	1241	52
Main	1263	1724	1392	1612	1376	63
Andrews	612	817	751	761	711	40
Central	892	1368	1385	1350	1251	42
Platt	1014	1056	1441[3]	727[3]	529	22
Smith	902	988	[1]	990[2]	1185	58
Driving Park	1416	1534	1829[3]	1646[3]	622[5]	20
Ridge Road	..	..	..	..	1011[4]	60
Stutson	168	212	184	221	196	29

[1] Smith Street Bridge rebuilt.
[2] New Smith Street Bridge opened for traffic in December 1930.
[3] Influenced by reconstruction of Smith Street Bridge.
[4] Ridge Road Bridge opened for traffic in December 1931.
[5] Influenced by opening of Ridge Road Bridge.

extensive traffic survey throughout the city on one day in April each year.

Methods of Repairing Metallic Bridges

Bolting, riveting and welding are three available methods of repairing or strengthening wrought iron and/or steel bridges, and adaptability of each of these methods to any structure should be studied before one is finally selected. If, in any case, numerous holes must be drilled in the old metal if bolts or rivets are to be used, and if welding be suitable, it will nearly always be found that welding will be quickest and cheapest.

Gasoline-driven welding machines must be used to generate the desirable welding current when electric power is not available for operating motor-generator welding sets. Machines of 300 amp. are of ample capacity for either wrought iron or steel; indeed, often 200-amp. capacity will be sufficient.

Oxyacetylene welding is also satisfactory for this service.

Before welding wrought iron or steel, the old metal should be thoroughly cleaned where necessary by hammering, scraping, wire-brushing or sand-blasting (on large projects) to remove oxides, dirt and paint. And, if the old metal is so badly corroded as to have edges too thin for welding, the thin part should be cut away with current, gas torch or other suitable means, to expose clean metal of sufficient thickness. This means a thickness at least equal to the leg of the fillet to be added, that is, from a minimum of $^1/_4$ in. to $^5/_{16}$ in., or $^3/_8$ in., the latter being the usual fillet sizes in common use for repairing bridges.

Electrodes for hand welding with 150 to 200 amp. should be $^5/_{32}$ in. or $^3/_{16}$ in. in diam. Fillets of $^3/_8$ in. or less should be deposited in one layer; $^7/_{16}$ in. to $^{11}/_{16}$ in. in two; $^3/_4$ in. to 1 in. in three. I have seen recently a set of specifications for welding a highway bridge in which three layers were required for $^3/_8$-in. fillets. I consider this an absurd requirement; one layer for a $^3/_8$-in. fillet is perfectly satisfactory.

Highway Bridge Floors

As existing metallic highway bridges are replaced or extensively repaired, the wooden plank floors so widely used in former times are being replaced by new types of steel or concrete. Experience with these new types is not of sufficient duration to give proof of their durability. Certainly they are in the experimental period. Seemingly, a considerable forward step has been taken when planking is replaced by these materials of more durable nature but, if these new concrete-steel combinations fail to show durability, it will be because the concrete may disintegrate under repeated bending stresses as was the case occasionally with concrete floors on buckle plates.

The rapidity with which wooden floors wear out is illustrated by accompanying Table 7, showing items of maintenance of Chester County (Pennsylvania) highway bridge No. 54. Built originally in 1887, the more important charges to planking are shown in the years 1893, 1913, 1923, 1927 and 1929. The 20-year period between 1893 and 1913 probably witnessed replanking, but the accounts show no record of it. Table 7 may not be complete, but is presented with the hope that it may stimulate more accurate and continuous records of maintenance charges of highway bridges. Table 8 presents similar maintenance charges from 1915 for a single span plate girder bridge carrying Grant St., Buffalo, over Scajaquada Creek. This bridge was built in 1890 at a cost of $23,799; three deck plate girders in one 55-ft. span; 2 sidewalks; plank flooring on roadway and walks; information furnished by F. D. Jackson of Buffalo's Department of Public Works.

Five of the more common types of new floors are: Bartruss reinforced concrete slab; steel-grid, such as tee-grid or T-tri-lok, with concrete filler; interlocking steel

Table 7—Original Cost, Maintenance Charges and Reconditioning Cost of Chester County (Pennsylvania) Bridge No. 54; Six Span Wrought-Iron Plate Girder Trestle

Year	Item	Cost	Year	Item	Cost
1887	Original cost	$7848.97	1926	Plank	$4.57
	Extras	292.67	1927	Plank	60.40
1891	Paint	290.00	1928	Probably paint	425.25
1893	Plank	339.00	1929	Probably plank	1830.30
	Probably labor	55.00	1930	....	25.30
1913	Plank	94.85	1931	Probably paint	389.75
	Repairs ?	945.00	1932	....	29.47
1921	Encasing column, bases, etc.	247.21	1932	Rebuilding	10,166.13
1922	Patching, etc.	116.38			
1923	New deck	1027.99			
	Paint	463.22			

Table 8—Maintenance Charges from 1915 for Grant Street One-Span Plate Girder Bridge, Buffalo, N. Y. Structure Built in 1890

	Maintenance Dollars					
Year	Structural	Sidewalks	Railings	Roadway	Foundation	Painting
1915	.....	....	.....	134.89	....	....
1916	.....	28.20	.....	189.05	....	....
1917	.....	51.39	176.45	384.68	....	227.62
1919	.....	108.70	108.70	118.93	....	....
1920	.....	72.80	.....	594.64	....	....
1922	.....	180.93	.....	169.38	....	....
1924	.....	....	1499.83	.....	....	....
1926	500.00	200.00	609.94	219.48	271.35	....
1927	.....	....	.....	1323.98	....	....
1929	.....	....	.....	293.25	....	....
1930	.....	....	.....	687.00	75.00	....
1932	1525.49	391.61	569.83	1141.19	....	....

NOTE: In 1932, 7-in. roadway I-stringers replaced by 12 in.; Roadway, 1¼-in. Carey Asphalt plank wearing surface on 3-in. white oak; sidewalks, new planks 2-in. Y. P.

channel with asphalt filler planks; flat steel plates. In each of the first three types mentioned, welding is used in shop fabrication; in the field, all are easily welded in place.

Bar-truss reinforced concrete slab, steel grid with concrete filler, interlocking steel-channel with asphalt filler planks were used, respectively, on three county highway bridges outlined in Table 9, showing the cost of reconditioning to have been from $2.02 to $2.26/sq. ft. of horizontal floor area, and field welding to have varied widely, from 263 lin. in. to 982 lin. in. per ton of steel added. Essentials of the rebuilding of these three structures are shown in Fig. 12. Stacey H. Widdicombe, associated with Carson and Carson, was consulting engineer of Chester County Bridge; Carson and Carson were also consulting engineers for the other county bridges. Harry K. Ellis and John S. Roberts, Jr., were county engineers of Chester and Bucks Counties, respectively.

Typical Welded Bridge Details

Figure 13, taken from railroad or highway bridges strengthened by welding, represent some possibilities. For adding cross-sectional area to upper and lower flanges of I- and built-up beams and plate girders, a narrow plate on an upper and a wide plate on lower flange, Fig. 13*A*, *B*, afford a simple solution to avoid overhead welding. But where necessary to secure lateral stiffness a plate wider than the top flange angles may be used even though overhead welding be required, Fig. 13*C*, *E*, *N*, and capable welders have no difficulty in doing work of this nature.

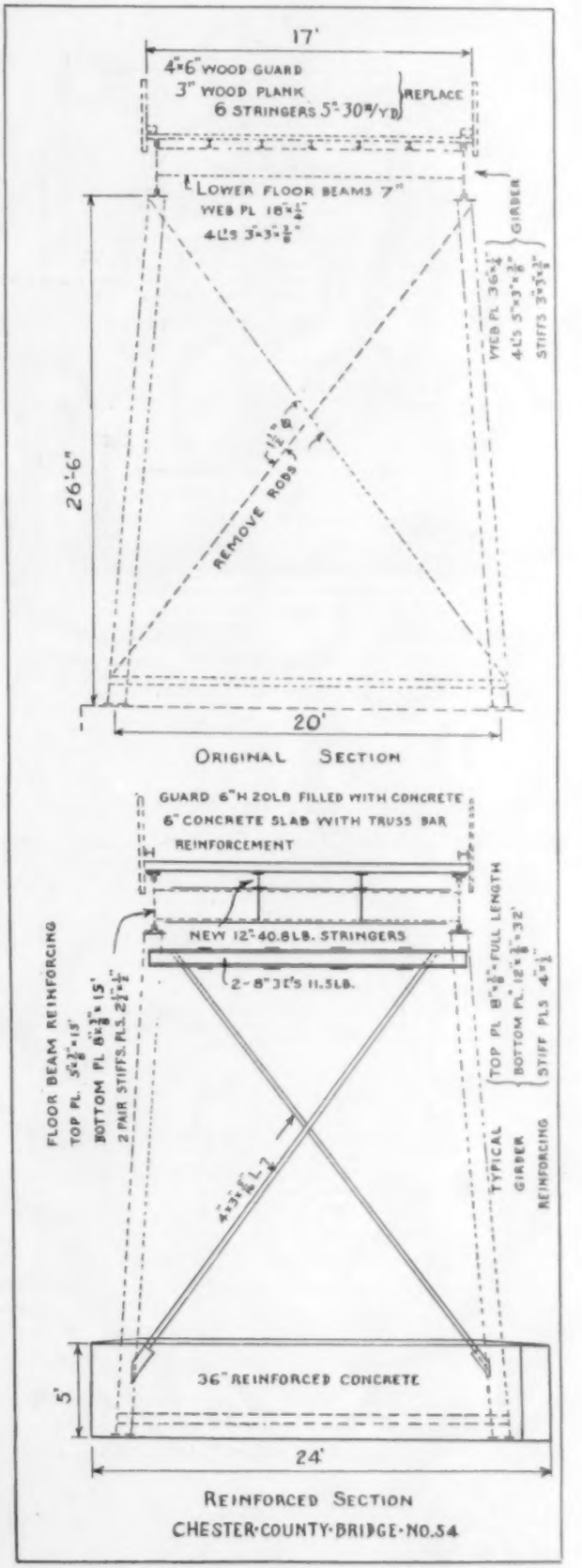


Fig. 12, Part I—Main Features of Reconditioning Three County Highway Bridges in Pennsylvania. See Table 9

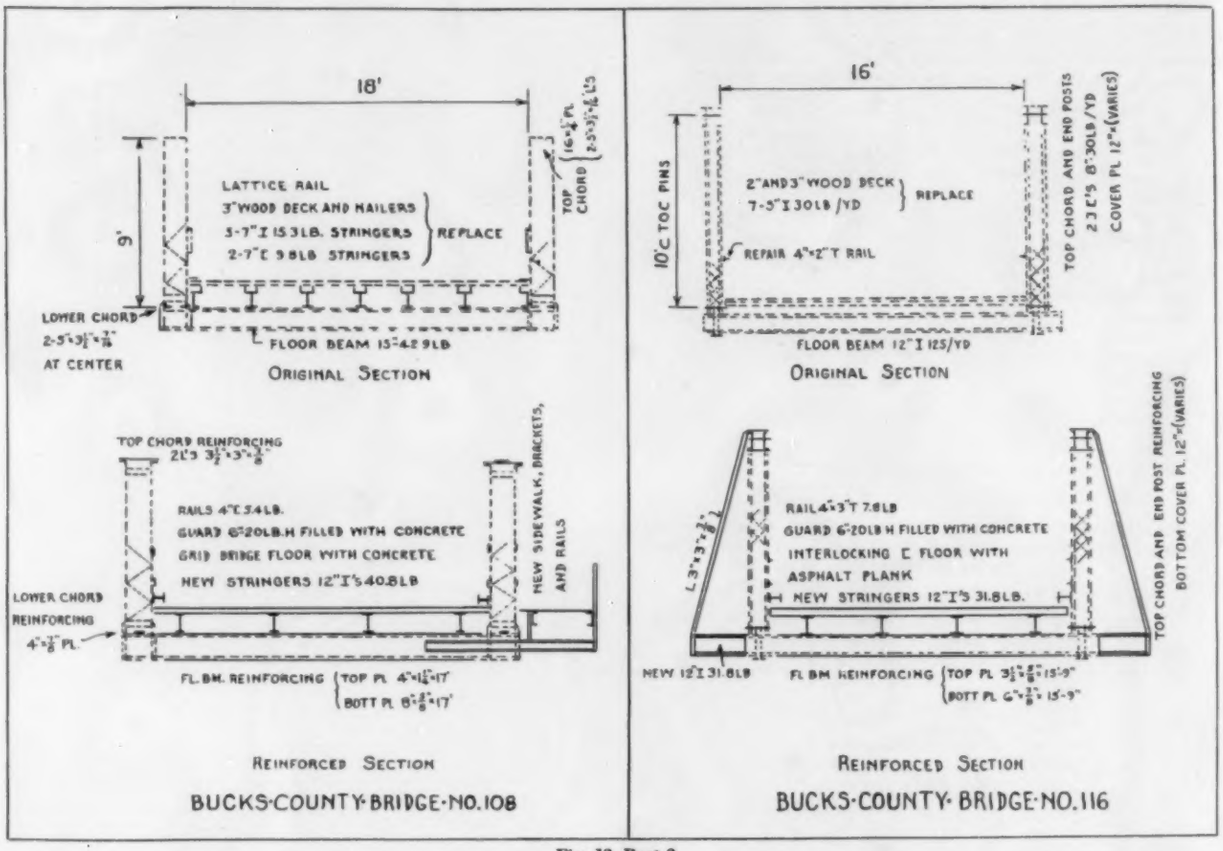


Fig. 12, Part 2

Table 9—New Decks and Arc Welding Used to Repair and Strengthen Three County Highway Bridges in Pennsylvania. See Fig. 12, Parts 1 and 2

	Chester County Bridge No. 54	Bucks County Bridge No. 108	Bucks County Bridge No. 116
Built originally	1887	1903	1879
Type	6 spans plate girder	2 spans pony-trusses riveted and bolted	2 spans pony-trusses pin-connected
Size, ft.	17x264	18x177	16x165
Area, sq. ft.	4490	3190	2640
Contract price for alterations	$10,160.00	$6534.00	$5333.00
Extras	$6.13	$140.00	0.00
Final cost	$10,166.13	$6674.00	$5333.00
Cost of alterations, $/sq. ft.	2.26	2.09	2.02
Structural steel added, tons	36	34	24
Floor deck steel added, tons	20	34	33
Total steel added, tons	56	68	57
5/16-in. fillets used in field, lin. in.	55,000	25,000	15,000
5/16-in. fillets used per ton of steel added, lin. in.	55,000/56 982	25,000/68 368	15,000/57 263
Type of new floor deck	Macmar	3-in. T-Tri-Lok	Belmont with J-M asphalt plank
Bridge closed to traffic, days	40	16	18
Original capacity, tons	2	4	4
New capacity, tons	15	15	15

Flat bars have largely superseded angles as web stiffeners, Fig. 13*H*, *J*, *M*.

Continuous rather than intermittent welding is preferable for bridge work.

The following notes apply to Fig. 13*A* and *B*, stringers or floor beams from several Chicago Great Western Ry. Bridges; *C*, *D*, *N*, Delaware, Lackawanna and Western Railroad bridge No. 42.30; *E*, use of plug welds for wide compression flange; *F*, highway bridge, Potter County, Pa.; *G*, Erie Railroad upper flange deck plate girder of 101-ft. span in Akron, Ohio, lower flange similar; *H* and *J* illustrate use of flat bars as stiffeners to strengthen a plate girder end bearing and a top flange of a floor beam, respectively; *K*, one type of a welded stringer-floor beam connection, with *L* as an alternate detail; *M*, stringer-floor beam connection strengthened by flat plate stiffener and welding; *O*, Chicago Great Western Ry. bridge F23, Waterloo, Iowa, column reinforcement; *P*, Chicago Great Western Ry., Missouri River Bridge at Leavenworth, top chord and end post reinforcement; *Q*, City of Philadelphia's bridge carrying Walnut Street over Schuylkill River, column reinforcement; *R*, Pennsylvania Highway bridge, welded plate reinforcing corroded jaw-plate; *S*, Bucks County, Pa., highway bridge No. 108, welded reinforcement of floor beam connection to riveted pony-truss; *T*, Bucks County, Pa., highway bridge No. 116, welded reinforcement of connection of floor beam connection to pin-connected pony-truss; *U*, Pennsylvania highway bridge, welded plate reinforcing corroded end-post web; *V*, distribution of weld reinforcing at back and toe of angle.

Comparative Loading Tests of Welded, Riveted and Bolted Floor Panels Made of Channels

In a series of tests to compare the behavior of Belmont rolled steel interlocking floors, alike except for use, re-

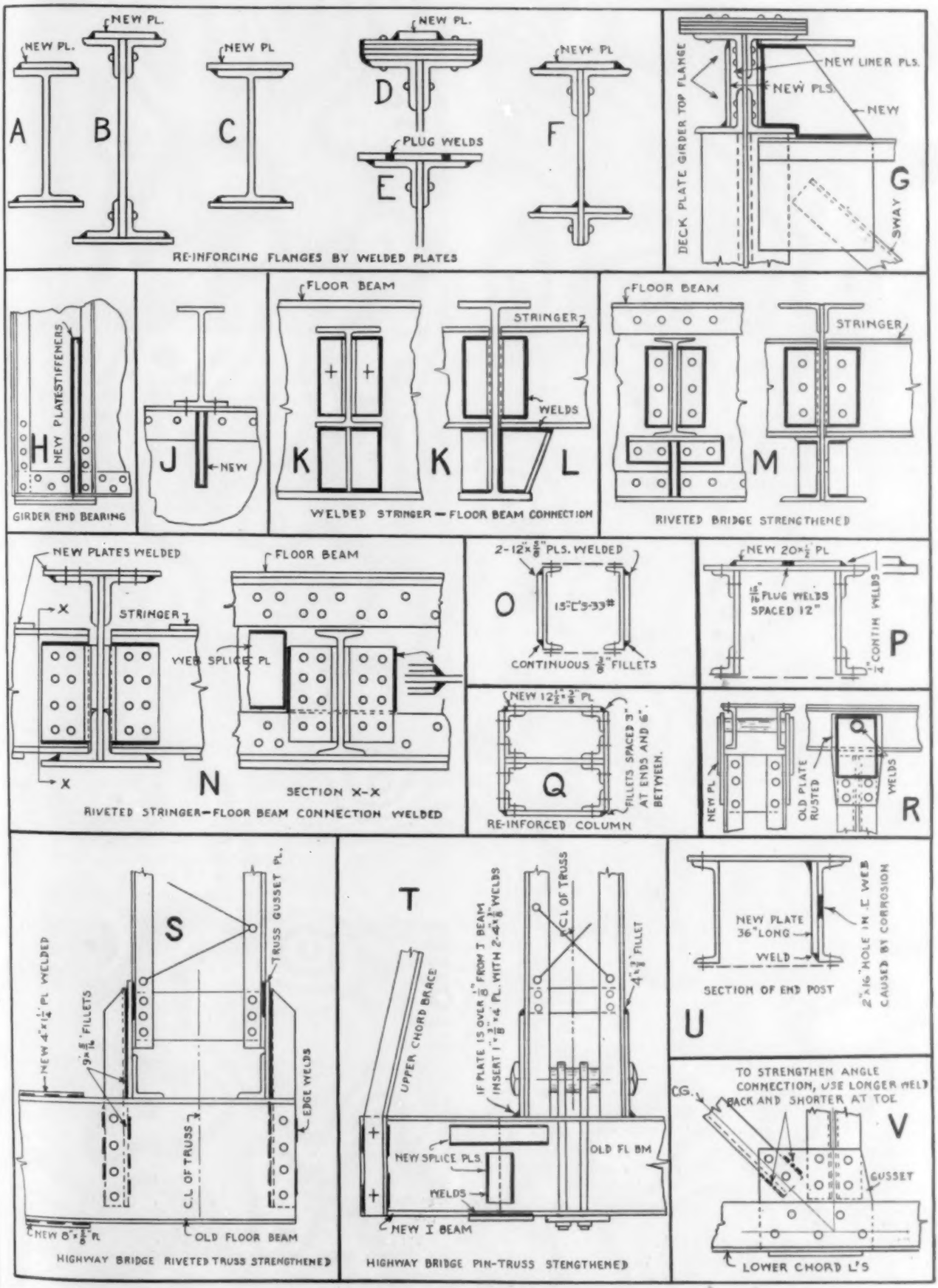


Fig. 13—Some Typical Welded Bridge Details

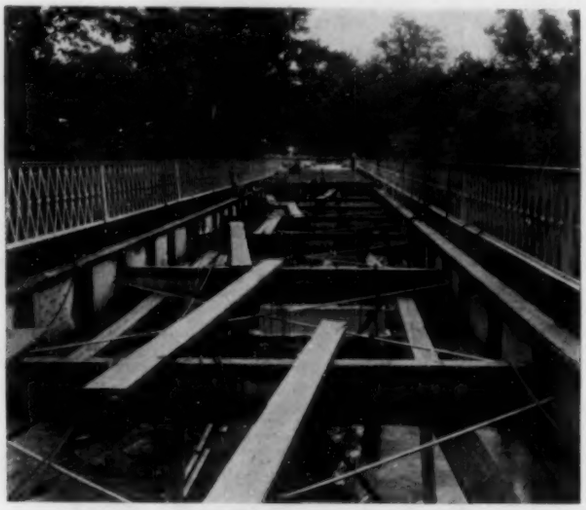


Fig. 14—Chester County, Pa., Bridge No. 54, Strengthened by Welding

spectively, of bolts, rivets or welds to connect the various channels together, the welded floor showed greater stiffness, that is, less deflections under test loads applied successively to each type of construction, Fig. 18.

Each of the three panels consisted of seven 12-in.x10.6-lb. stair channels interlocked and connected either by $^1/_4$-in.x1-in. fillet welds or by $^1/_2$-in. rivets or by $^1/_2$-in. bolts, spaced 12 in. on centers, respectively, Fig. 18. For riveted or bolted types, the rivets or bolts are necessarily spaced midway at the depth, that is, at the center of gravity of the combined section; whereas, in the welded floor, the intermittent fillets are located near the upper and lower parts of the channels.

Each floor panel of seven channels, after being fabricated as above described, was placed in turn on a testing table, loaded with continuous uniformly distributed loads of four varying amounts, namely, 125, 185, 265 and 380 lb./sq. ft., respectively, on two adjacent equal 10-ft. spans. This made each floor continuous over the central support of two equal spans.

Vertical deflections were recorded at points *A* and *B*, each 4.215 ft. from its nearest end support, Fig. 18, these being the points in each span at which the deflections for uniform load are theoretically greatest on beams having two equal spans continuous over the central support.

For uniformly distributed loads, above described, the deflections were least for the welded floor, next greater for the riveted, and greatest of all for the bolted type; being for the 380 lb./sq. ft. loading, $^{18}/_{32}$ in., $^{27}/_{32}$ in. and $^{33}/_{32}$ in., respectively, for the three floors.

Likewise, the permanent sets were least for welded, intermediate for riveted and greatest for bolted floors, Fig. 18.

Structural Steel Welding Committee's Qualification Tests for Welders

The AMERICAN WELDING SOCIETY's report of the Structural Steel Welding Committee, September 1, 1931, recommends (*a*) a preliminary wedge test, and (*b*) tension test on either one of three types of specimens, Fig. 19.

The wedge test, Fig. 19*D*, is intended to determine whether the welder possesses sufficient skill to proceed with the tension test. At least two specimens are to be tested.

The tension test may be on butt welds, Fig. 19*B*, or on either the end fillet specimen, Fig. 19*A*, or on the side fillet specimen, Fig. 19*C*. The eight tensile coupons from butt-welded joints with reinforcement ground off should show a minimum ultimate strength of throat of 45,000 lb./sq. in. with average for the eight specimens of 52,000 lb./sq. in. The two fillet-welded specimens of either type chosen (end or side) should show a minimum ultimate strength of 12,000 lb./lin. in. of weld, equivalent to a total load on the specimens of 72,000 lb.

Strange to relate, the Society's "Code for Fusion Welding and Gas Cutting in Building Construction, Edition of 1930," sets forth no specific tests for qualifying welders, but contents itself with the statement that "Contractors for welded structures shall be required to satisfy the Superintendent of Buildings as to their ability to produce satisfactory welded joints of the forms specified, and with the process (arc or gas), materials and equipment to be used on the proposed work."

Actual Qualification Test Results for Field Welders, Chester County, Pennsylvania, Bridge No. 54

Tables 10 and 11 give actual results of qualifying four welders for a highway bridge where three types of tests were required, namely, lap, butt and side fillet welds.

It will be observed that these tests are more searching than the "Author's Recommended Tests for Qualifying Operators Engaged in Welding Bridges or Buildings" suggested elsewhere in this article. Tables 10 and 11 reveal:

(*a*) Butt-welded specimens, Table 10, were made of steel plates and steel electrodes; welders Nos. 1, 2, 3, 4 using bare-steel electrodes, welder No. 44 using coated steel electrodes.

Average tensile strength of 32 butt-welds with bare wire in 51,600 lb./sq. in. Average tensile strength of 8 butt welds with coated wire is 58,600 lb./sq. in., an increase of 13.6 per cent over the strength of bare-wire specimens.

Tensile strengths of flat and of vertical butt welds are practically the same.

(*b*) Fillet-welded specimens, Table 11, were made of wrought iron plates and steel electrodes; welders Nos. 1, 2, 3, 4 using bare-steel electrodes; welder No. 44 using coated steel electrodes.

Average total longitudinal shear at failure for 4 flat-welded side fillet specimens is 54,810 lb., or 9140 lb./lin. in. of $^5/_{16}$-in. fillet; and for 4 vertical-welded side fillet specimens 59,080 lb., or 9850 lb./lin. in. of $^5/_{16}$-in. fillet. The vertical-welded specimens exceed, as usual, the horizontal; in this case by about 8 per cent.

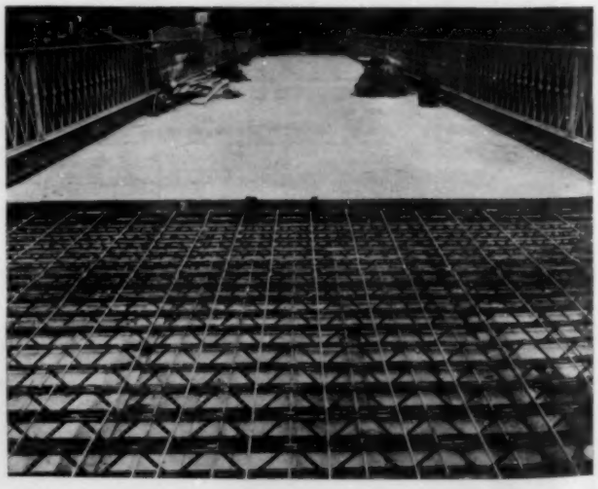


Fig. 15—Chester County, Pa., Bridge No. 54. New Concrete Deck Being Placed on Macmar Welded Bar-Truss Reinforcement

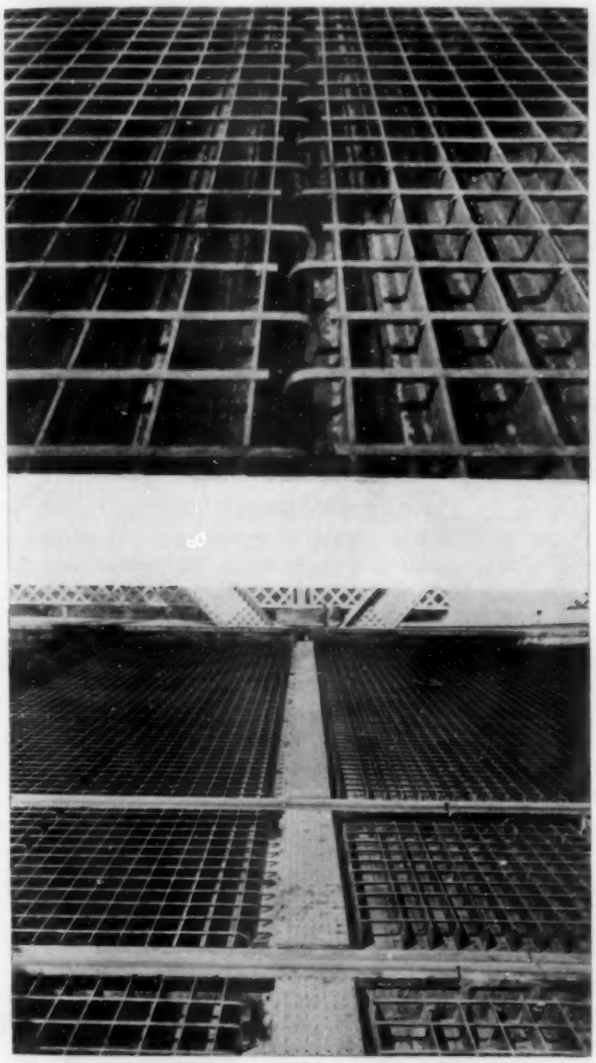


Fig. 16—Truscon Welded Tee-Grid Bridge Floor before Placing Concrete. Hamilton Street Bridge, Allentown, Pa., April 28, 1932

The Writer's Recommended Tests for Qualifying Operators Engaged in Welding Bridges or Buildings

It goes without saying that welds must be safe; that welding contractors should show their ability to supervise and that of their welding operators to perform the work satisfactorily. But there is a tendency to require too many tests. Too much emphasis has been placed on qualification tests. Constant reference to tests engenders a feeling of fear regarding the safety of welding processes. Fear comes from inexperience, from ignorance.

In Shakespeare's tragedy, *Julius Caesar*, the great Caesar says:

"Cowards die many times before their deaths;
The valiant never taste of death but once.
Of all the wonders that I yet have heard,
It seems to me most strange that men should fear."

Welding is as safe as are any of the other processes of the industrial arts, riveting or concreting, for example. All I ask of those in high places who are fearful is to take Cardinal Wolsey's advice given to his Cromwell in Shakespeare's *King Henry VIII*—"Be just and fear not."

But

"Bring me to the test,
And I the matter will re-word."—*Hamlet.*

For important steel bridge or building construction the following requisites should be insisted on, but in many

Table 10—Actual Qualification Test Results for Four Welders. Double V-Butt Arc-Welded Structural Steel Plates with Reinforcement Ground Off and Cut into Tension Test Specimens Approximately $2^1/_4 \times {}^1/_2$ In., in Cross Section. Alteration of Chester County (Pennsylvania) Highway Bridge No. 54

Each Value Is an Average of Results from Four Tension Test Specimens

Welder's Number	Plate Welded Flat or Vertical?	Average Stress Lb./Sq. In. Yield Point	Ultimate Tension
1	F	32,400	49,600
	V	33,700	51,800
2	F	33,400	53,400
	V	33,200	52,300
3	F	35,100	51,900
	V	34,900	52,400
4	F	34,000	51,500
	V	33,800	49,900
44*	F	36,000	59,050
	V	35,400	58,150

Summary of Above Tests	Average Ultimate Tension, Lb./Sq. In.
16 Flat (bare wire)	51,600
16 Vertical (bare wire)	51,600
32 Flat and vertical (bare wire)	51,600
4 Flat (coated wire)	59,050
4 Vertical (coated wire)	58,150
8 Flat and vertical (coated wire)	58,600
20 Flat (bare and coated wires)	53,090
20 Vertical (bare and coated wires)	52,910
40 Flat and vertical (bare and coated wires)	53,000

* Second test for Welder No. 4. Welders Nos. 1, 2, 3, 4 used bare electrodes. Welder No. 44 used coated electrodes.

Table 11—Actual Qualification Test Results for Four Welders. Wrought Iron Plates, Steel Electrodes, Side Fillet Welds, $^5/_{16}$ In. Tested in Longitudinal Shear, Alterations of Chester County (Pennsylvania) Highway Bridge No. 54

Each Welder Made One Flat and One Vertical Specimen. All Craters Were Filled

Welder's Number		Total Length of Four Fillets per Specimen, In.	Total Load at Failure, Lb.	Load per Lin. In. at Failure, Lb.	Average Load per Lin. In. at Failure, Lb.
1	F	6	55,550	9260	
	V		57,900	9650	9450
2	F	6	56,250	9380	
	V		62,670	10,450	9910
3	F	6	55,370	9230	
	V		59,900	9980	9600
4	F	6	52,070	8680	
	V		55,850	9310	9000
44*	F	6	52,470	8750	
	V		59,480	9910	9330
Summary of above specimens:					
4 Flat (bare wire)			54,810	..	9140
4 Vertical (bare wire)			59,080	..	9850
1 Flat (coated wire)			52,470	..	8750
1 Vertical (coated wire)			59,480	..	9910

* Second test for Welder No. 4. Welders Nos. 1, 2, 3, 4 used bare steel electrodes. Welder No. 44 used coated steel electrode.

minor projects, the preliminary wedge test, outlined in paragraph *A* below, is ample:

Welding operators shall be experienced in structural welding. They may be required, in the presence of the inspector, to weld in each of the positions (flat, vertical, overhead) that will be required in the welder's subsequent work on this structure, test specimens, which shall meet the dimensions of Fig. 20, and the requirements of paragraphs *A* and *B* hereinafter. The specimens shall be made with the same quality of welding wire and steel, with similar equipment, and under similar conditions, as those to be used subsequently in the structure. Once each week during the progress of the work, each welder shall weld satisfactorily one preliminary wedge test.

A. Preliminary Wedge Test.—Each welding operator may be required to weld two specimens, each made of two $^1/_2$ x 6 x 8-in. medium steel plates clamped one on the other with the 8-in. edges lined up but with the 6-in. edges offset $^1/_2$ in. A full $^1/_2$-in. fillet is then to be made along one 6-in. edge, two layers to be used, the surface of the first to be thoroughly cleaned before the second layer is added, Fig. 20*A*.

Upon completion of the weld and after cooling, the specimens shall be torn apart and broken by wedging at the unwelded 6-in. edges. The fractured metal shall show good fusion of welds and parent metals; good penetration into right-angle corner of the fillet; bright, dense, even textured, crystalline or fibrous weld metal; irregularly torn and void of iridescent colors.

B. Final Tension Test.—Each welding operator may be required to weld two medium steel specimens, Fig. 20*B*, in each of the positions (flat, vertical, overhead) that will be required in the welder's subsequent work on this structure. The $^3/_8$-in. fillets shall be deposited in one layer and craters shall be filled. Each specimen when tested in tension should show at least an ultimate strength of 12,000 lb./lin. in. of weld; equivalent to a total load on the specimen of 72,000 lb.

Permissible Unit Stresses for Buildings and for Highway Bridges

The AMERICAN WELDING SOCIETY's "Code for Fusion Welding and Gas Cutting in Building Construction" states that welded joints in steel building frames shall be proportioned so that stresses therein shall not exceed the following in lb./sq. in. on sections taken through throat of the weld—shear 11,300, tension 13,000, compression 15,000; and these values were experimentally verified by the Structural Steel Welding Committee's report* containing results of nearly 2500 tests.

For designing welded joints in highway bridges in which an allowance for impact is otherwise provided for, 80 per cent of the above values seem desirable; that is, unit stresses shall not exceed the following in lb./sq. in. on throat sections: shear 9000, tension 10,400, compression 12,000. If all welders in highway bridge construction were properly qualified and if all work of this nature were adequately inspected and supervised, the permissible unit stresses could be those of the AMERICAN WELDING SOCIETY. But, because of the wide geographical distribution and varying conditions under which highway bridge construction is carried on, especially in the field, the above recommended values of permissible unit stresses seem desirable; namely, 80 per cent of AMERICAN WELDING SOCIETY's unit stresses for buildings.

Table 12, showing permissible safe unit stresses in lb./lin. in. of triangular fillets, is based on shears of 11,300 lb./sq. in. of throat section for buildings and 9000 lb./sq. in. of throat section for highway bridges.

* Obtainable at AMERICAN WELDING SOCIETY, 33 W. 39th St., New York City.

Table 12—Safe Permissible Unit Longitudinal Shearing Stresses per Lin. In. of Triangular Fillet Welds; at 11,300 Lb./Sq. In. of Throat Section for Buildings and 9000 Lb./Sq. In. Throat Section for Highway Bridges

Leg of Fillet, In.	Longitudinal Shearing Stresses per Lin. In. of Fillets, Lb. Buildings at 11,300 Lb./Sq. In.	Bridges at 9000 Lb./Sq. In.
$^1/_4$	2000	1600
$^5/_{16}$	2500	2000
$^3/_8$	3000	2400
$^7/_{16}$	3500	2800
$^1/_2$	4000	3200
$^9/_{16}$	4500	3600
$^5/_8$	5000	4000

Steel Homes

A fertile field lies fallow, uncultivated. It should be tilled with the same thoroughness as that already exerted by steel companies in other endeavors, notably in multi-story steel buildings and bridges, and by electrical and gas companies in expanding the markets for welding and flame cutting of steels. I refer to the opportunity of

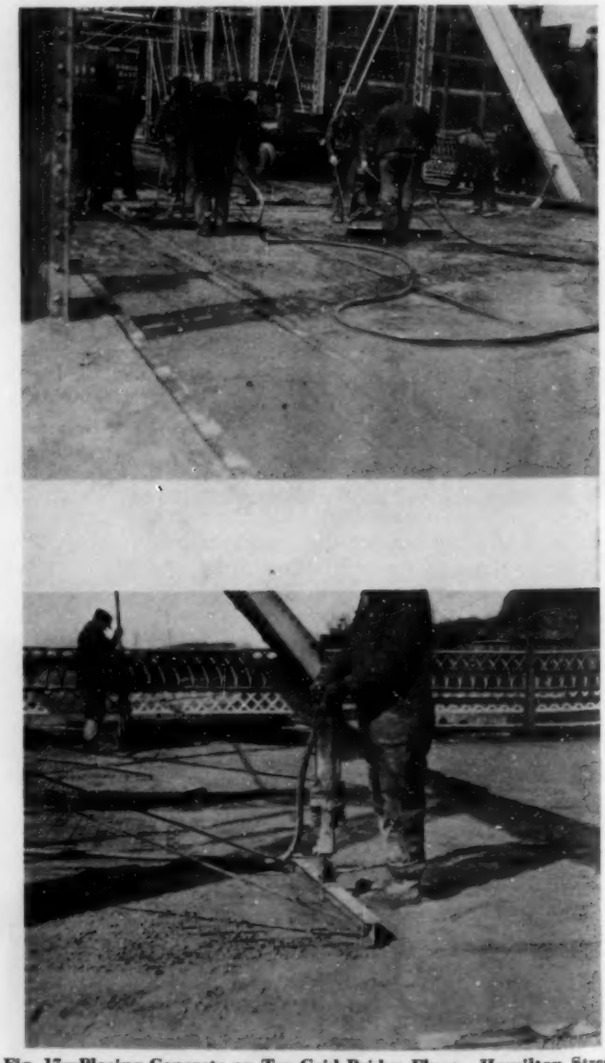


Fig. 17—Placing Concrete on Tee-Grid Bridge Floor. Hamilton Street Bridge, Allentown, Pa., April 28, 1932

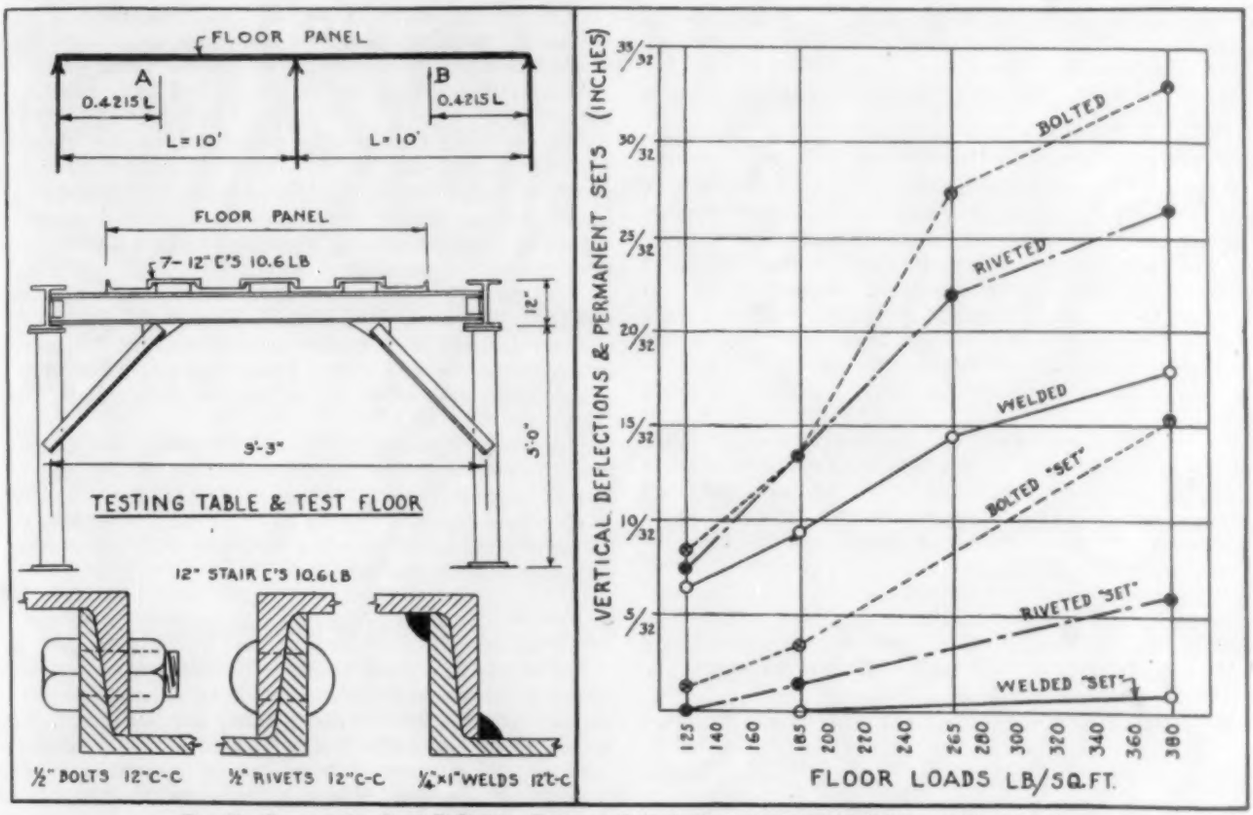


Fig. 18—Comparative Load-Deflection Tests on Bolted, Riveted and Welded Belmont Floor Panels

using steel in the construction of homes. Assuming a need of 10 tons of steel in channels, beams, angles and bars to form the framework to support walls, floors, partitions and roofs in each of 200,000 homes, a potential annual market of 2,000,000 tons of steel is awaiting development.

But to bring this to fruition is no small task, because it involves considerable effort in educating architects to recommend, builders to supervise and artisans to construct; and, although steel homes have been erected, their number is infinitesimal in comparison with the possibilities.

The steel skeleton may be fabricated in shops complete, shipped to the building site ready for bolting or welding or the steel may be sent directly to the site to be there cut to the proper sizes and shapes for erection. With steel door and window frames, tile floors on concrete slabs supported on steel beams or joists, with exterior walls of brick, interior walls of plaster on metal lathe or

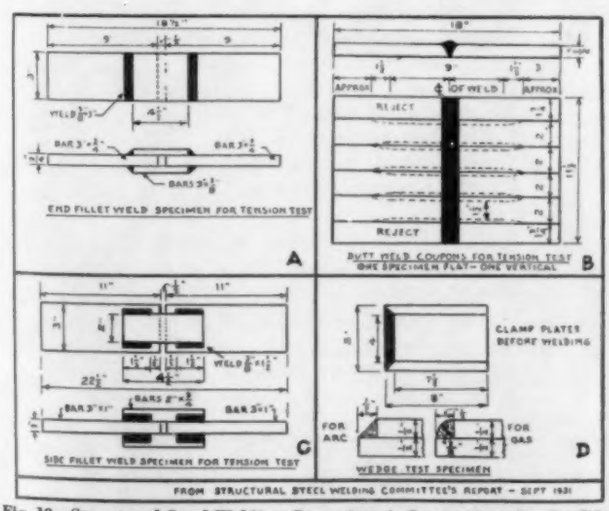


Fig. 19—Structural Steel Welding Committee's Suggestions for Qualifying Welders. Wedge Test (*D*) Is Preliminary. Either Butt-Weld (*B*), End Fillet (*A*) or Side Fillet (*C*) Is Final Test

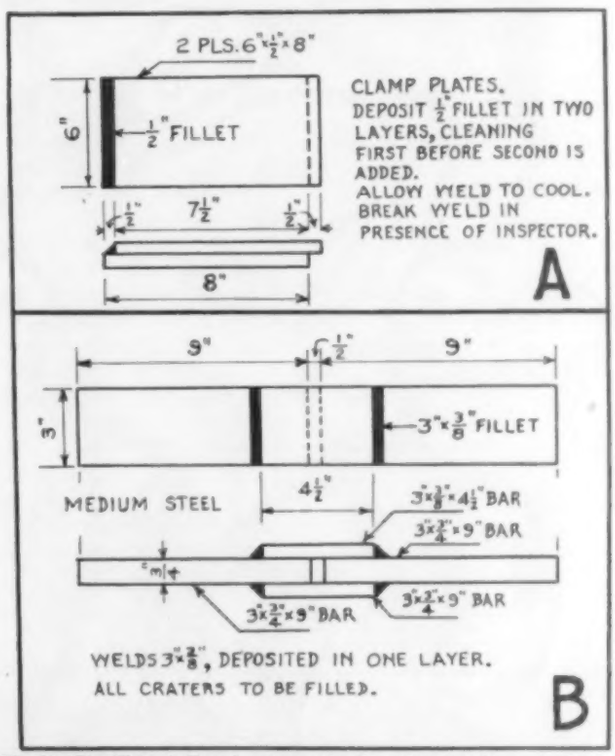


Fig. 20—The Writer's Test Specimens for Qualifying Welders; for Buildings or Bridges. (*A*) Preliminary Wedge Test. (*B*) Final End-Fillet Test

hollow tile, there results a fire-resisting, vermin-proof, noise-retarding structure, involving lower insurance rates and smaller depreciation charges than now obtain for the more common types of construction used in home building.

Flame Cutting

Oxyacetylene or flame cutting is in common use in structural steel fabricating shops for such operations as copying or blocking beams, channels and other shapes. Its use in cutting tee-shaped brackets from I-beams to serve as connections of flanges of floor beams to columns to transmit bending moments resulting from wind or other forces in buildings, is an illustration of its great adaptability in the fabricating shop. With careful manipulation, oxyacetylene cutting admits of great accuracy.

But while many structural engineers permit flame cutting in coping and similar operations, they are more conservative as to its substitution for milling. For example, the Report of Committee XV—Iron and Steel Structures of the American Railway Engineering Association—submitted as information, reveals a set of rules for fusion welding and gas cutting for steel structures including bridges and buildings, in which the following are the chief items pertaining to flame cutting:

"The contractor shall satisfy the engineer as to his ability to produce satisfactory gas cuts."

"Gas-cut edges shall be smooth and regular in contour."

"Gas cutting may be used in the preparation of base metals for welding, provided the edges so cut are thoroughly cleaned after cutting to expose clean steel."

"Gas cutting shall not be permitted as a substitute for milling."

"Gas cutting shall not be permitted on any member while it is carrying stress. This restriction shall not apply to detail cutting for the correction of minor fabricating errors, where the removal of melted material resulting from gas cutting would not reduce the required strength of the member if so cut."

"Gas cutting of holes in a member which has not been designed therefore, shall not be permitted."

After having seen innumerable flame-cut edges and innumerable sheared edges, I am of the opinion that in many cases where the former are carefully made, they are superior to the latter.

A series of bending tests, made in the Union Carbide and Carbon Research Laboratories, on small bars cut respectively by shears, flame cutting, milling and the friction saw, indicate (Table 13) that flame cutting when properly used takes its place on a par with other severing processes in steel fabrication.

Table 13—Comparative Bending Tests on Small Bars Cut From I-Beam Webs or Angles by Flame Cutting, Machining, Shearing or Friction Saw

Machined Bars (*No Fractures*)		Oxyacetylene Cut Bars (*No Fractures*)	
Steel Plate:		Steel Plate:	
Load 1575 lb.	Bent 180 deg.	Load 1725 lb.	Bent 180 deg.
1575 lb.	Bent 180 deg.	1580 lb.	Bent 180 deg.
1600 lb.	Bent 180 deg.	1700 lb.	Bent 180 deg.
Av. 1580 lb.		Av. 1670 lb.	
I-Beam Web:		I-Beam Web:	
Load 1455 lb.	Bent 180 deg.	Load 1605 lb.	Bent 180 deg.
1425 lb.	Bent 180 deg.	1625 lb.	Bent 180 deg.
1470 lb.	Bent 180 deg.	1640 lb.	Bent 180 deg.
Av. 1450 lb.		Av. 1625 lb.	

Sheared Bar

Steel Plate:	
Load 1290 lb.	Bent 43 deg. and cracked
1280 lb.	Bent 38 deg. and cracked
1190 lb.	Bent 31 deg. and cracked
Av. 1250 lb.	Bent 37 deg. and cracked

Friction Sawed Bar

Angle Iron:	
Load 1840 lb.	Bent 18 deg. and cracked
1400 lb.	Bent 24 deg. and cracked
1610 lb.	Bent 34 deg. and cracked
Av. 1620 lb.	Bent 25 deg. and cracked

What of the Future?

For nearly five years ending 1919 the world feverishly made and destroyed war materials in unheard of quantities. Now for over three years, production of economic goods has all but ceased, while men either have been depriving themselves of necessities or consuming their surplus goods. It seems, therefore, that in face of these depleted stores we can view the future prospect with a courageous spirit, because sooner or later the deprivations to which we are now subjected will result in industrial activity of substantial nature. In the meantime let us prepare ourselves physically, mentally, spiritually so that we may then, and now, appreciate the real values of life. As I sit in my study and between these lines view on the one hand a beautiful forest extending many miles along the Blue Ridge Mountains, while stretching equally far in the opposite direction lies a peaceful and fertile valley, I see only the optimistic aspects of a distressed but improving world. And as night obscures mountain, valley and distress, while my fireplace gives forth its flickering cheer, I recall Longfellow's words:

"Burn, O evening hearth, and waken
Pleasant visions, as of old!
Though this house by winds be shaken,
Safe I keep this room of gold!

Ah, no longer wizard fancy
Builds her castle in the air,
Luring me by necromancy
Up the never-ending stair!

But, instead, she builds me bridges
Over many a dark ravine
Where beneath the gusty ridges
Cataracts dash and roar unseen."

Reprints of the complete paper by Prof. McKibben are available at Society Headquarters, at 35 cents per copy.

Must Industry Be a Pawn or a Power?

By CHARLES F. ABBOTT

✦Paper presented at Friday Morning, April 28th, Session of Annual Meeting, A. W. S. by Charles F. Abbott, Executive Director, American Institute of Steel Construction, Inc.

NO MORE valuable contribution has ever been made to American business or to the public at large than the trade association developed and promoted under the guidance of Mr. Hoover when Secretary of Commerce.

During 1931 over 19,000 such associations, according to the Department of Commerce, were actively engaged in programs of standardization, simplification, elimination of waste, cost reductions and similar activities that have actually saved hundreds of millions of dollars that otherwise the public would have paid.

The welding of many separate business concerns into group activities for their common good, thereby placing the welfare of the industry ahead of individual gain, is the principal idea of this modern trade association.

The efficient association is one reason for America's famed teamwork in business. It inculcates enlightenment in place of selfishness, a generosity on the part of the big fellow to help the little fellow. It has already taught us that the main secret of a successful business and a happy life is to climb from retaliation to reciprocity.

There was never a time when the important function of the trade organization has been so definitely tested and proved as during the past three years. Its stabilizing influences have been constantly at work, and to a large extent it has prevented what might have been a far more serious situation. The results could not always be widely advertised, yet their effects have been direct and apparent. We have gone through the greatest economic depression in history without any serious uprising or any violent social disturbance.

A trade association functions as the spokesman for its industry. It is ever on the alert to protect and promote the interests that it represents. It preserves public welfare and forms an immediate contact with the government in times of emergency.

The trade association can be depended upon to marshal support for constructive legislation and prevent radical impractical laws. But industry's voice in that activity is weak and ineffectual unless it is backed by a strong association, an organized leadership.

About eight years ago some officials of the European steel industries corresponded with the American Institute of Steel Construction and later personally obtained ideas that were incorporated into programs over there. Today, these same European countries maintain steel associations that are much broader and far more active than any maintained by the steel industry in this country. This affords food for thought because these countries are now actively engaged in staging a comeback, preparing themselves for the better years ahead.

Organized cooperation, supporting a practical program, opens the way for important accomplishments that advances an industry. Research to develop new uses, new markets and reduce costs, advertising, education and many similar activities, can be more economically and effectively promoted than would be possible if left to individual action.

There should be no doubt, no hesitation, in the acceptance and application of wholesome cooperative effort among competitors. It offers the only way to a larger business and a better business. There is no other. Either competition will fall to the level of trade demoralization or it must adopt a practical plan of cooperation.

During the past three years of the depression some unjust criticism has been cast upon trade associations. Governments throughout the world have been faced with a similar problem. It is but natural that, in an era of unrest, our trade associations should be the focal point of industrial discontent. They have been frequently condemned for not stemming the tide of competition, for not bringing an end to the distress of unemployment or for not making values rise again to the heights that prevailed in 1929.

Most of this criticism has been unfair and unwarranted. The fault, if any, did not rest with the associations or the executives in charge. Leadership was available, but it became helpless when members insisted upon resigning, inspired by selfishness or actuated by the false belief that they could ride and benefit while their more progressive competitors paid the bill.

It has proved to be an expensive experience. This withdrawal of support nearly brought about a complete collapse of industrial organization at a time of all times when so much was expected of business leadership.

The indictments of a distressed public have to this extent been justified, but the blame should be placed where it belongs, not upon the trade association itself, but upon the non-cooperator who has and will continue to be the greatest menace to industrial progress. This is particularly true in the years to come when so many radical changes are sure to take place throughout all of our business undertakings.

The time has arrived when trade associations must be supported if they are to assume leadership. This is sorely needed if industrial solidarity is to survive. Industrial individualism, if persisted in, will but further delay recovery.

A responsibility rests with industry to promote organized leadership. It should be done through trade associations, not alone for selfish business reasons, but in recognition of the trust imposed in business managements by the public and the labor employed by industry. Public welfare is at stake and unless this evident drifting gives way to a comprehensive program we will be encouraging communism. If our leaders fail in a time of stress, there should be no criticism if the populace seizes the initiative which a disorganized capitalistic system cannot or will not assume.

The public is depending upon business men for improvement in business. The unemployed are anxiously awaiting an opportunity to return to work.

Mr. Gerard Swope, President of the General Electric Company, contributed a plan for the stabilization of industry. It was a well-conceived, practical program. It provides for a compulsory membership in trade associations, which is vital if industry is to assume its responsibility. Recognition was given to the rights of employees and in many other ways it was in keeping with the times. But like other progressive proposals, Mr. Swope's plan was evidently ahead of the times as there are still too many business men who believe that business does not need a plan.

The possibilities of success under proper direction and

control should be apparent to all. The question is, will our industries recognize their opportunity and overcome their attitude of indifference that is inviting a policy of disorganized drifting?

It is advisable to consider briefly some of the responsibilities that must be assumed.

Business exists for making profits. When profits disappear, business likewise disappears. The satisfaction of labor working for an adequate wage, of the consuming public for an adequate supply of goods at reasonable prices, of the investor for a return on his money, of the government for an unimpaired source of tax returns, are all dependent uniformly upon the profitable operation of business. This problem of earning a profit, however, is properly left to the discretion of business management. Consequently, management is in duty bound to apply scientific thinking and planning in effecting better methods for the stabilizing of business prosperity.

Every business enterprise is fundamentally a public service undertaking. It can make good and should be allowed to exist only in proportion as it recognizes the public character of the function it is performing. Uniformity of prices and of the treatment of customers until the time comes when there is reason for uniform change, with full publicity for the change, is the course upon which the interests of all can be reconciled—and the only one.

Business men must recognize the need of eliminating the destructive competitive practices, such as price cutting, that destroy profits and incur losses when goods are sold below the cost of producing them.

The profit record in most of our basic industries, such as oil, coal, lumber, metal, textile, rubber, food and others has been anything but encouraging. We have been dissipating important natural resources at a loss. Under such conditions public welfare is adversely affected.

Goods that must be sold at a loss represent so much capital and labor thrown away. Distress sales inevitably result in a curtailment of industrial activity and unemployment. When industry is profitable, labor is profitable, and these profits are spent for goods. When industry is unprofitable, labor is thrown out of employment and consumption is reduced, thus causing a vicious circle.

The profitable operation of our industries during the active period from 1922 to 1929, when volume was large, was a problem of even greater importance than during the past three years of recession.

If profitable operation is impossible in a period of active demand, then we have every reason to expect dire distress when we enter a period of temporary business decline.

It is a mistake, however, to think that price fixing is the ultimate aim of a trade association. American business is volatile and requires greater freedom than would be permitted under any definite plan of price fixing. But that is no indication that we do not require greater stabilization in our marketing plans, and I firmly believe that we can attain it effectively, within the prohibitions of our existing laws.

We can do much more with the agencies we now have and without upsetting the capitalistic principle upon which our business is based. We must look beyond immediate orders and prices. We must throw overboard any faith in unsound or artificial agreements, designed to control such fundamental, economic forces as orders and prices. It is a fallacy, during times like these, to attach any hope to any system of compulsion designed to divert world-wide influences.

I personally do not believe the Sherman Law, or any of the anti-trust statutes since enacted, prohibits that form of trade cooperation that is essential to achieve these ends. But the interpretations given by some political office-holders under those laws are such as to make the effort decidedly hazardous.

Many organizations have been studying the problem for the past two or three years. As a result of these studies the feeling prevails that a slight modification of the Anti-Trust Laws, to permit the control of production output in accord with consumption demand, be applied to our natural resource industries. That would prove helpful and without impairing public welfare.

Stabilization of these industries would conserve natural resources and would undoubtedly develop a constructive influence over all other business enterprises.

The day is fast arriving when the public will realize more fully the fundamental necessity of insuring us against bankruptcies and of improving the profit standing of those who engage in business. Politically, we are just awaking to the fact that if we desire to organize trade and industry, to maintain the wage scale and employment, it is necessary to permit trades and industries to earn reasonable profits.

The lesson of cooperation as advocated by the trade organization has prevented many a costly price war that otherwise would have proved expensive and disastrous for the entire industry. Without the trade association there is no assurance of a normal stability of an industry. An instance so small as the releasing of a destructive cut price policy, usually inspired by some imaginary grievance and by a single company, will kindle the flames of bitter retaliation and all the evil consequences of greeds, animosities, hates and jealousies.

A well-organized trade association offers the sole hope of preventing impulsive acts. The appeal to justice and fairness usually succeeds in quieting the vicious thoughts that flash in the heat of temper.

One of the important purposes of an organization is to establish the confidence upon which honesty is based. Without honesty there can be no agreements. Honesty can be established as relationships increase, and confidence will replace suspicion. It is a hopeless task to place too great a reliance upon mutual agreements until honesty can become an inherent part of man's character.

Our strongest weapon is education. By hammering indisputable facts home again and again to every member of an industry the influences that promote price cutting can be reversed. Education should start by destroying the illusion that greater profits can be obtained from an increase in volume secured by price cutting. When this illusion has been destroyed, the root of the price cutting evil will be eliminated.

We can do much to effect this education through cooperation, through coming together and honestly discussing our problems. Around a conference table, in trade association meetings, this education is possible and without circumscribing the rights of individuals.

But, the more permanent, outstanding accomplishments of trade associations are those programs that were designed to meet the external problems of an industry and that included a direct approach to the market for the industry's output. Research to develop new uses and new applications, market analysis, the protection and extension of existing markets, education and many other similar activities that might relate to distribution, costs and public welfare all reflect the broader and more effective schedules of the progressive trade association.

The direct approach to better prices and insured profits is through an increase in consumption that

would more nearly approach the ability of the industry to produce.

It is easy to understand why so many executives attach less importance to cooperative activities directed toward the market than to those internal questions that relate to prices and competition. Many of them have received their early training in the plant or factory. They became and still remain production-minded. They were efficient in dealing with machines, formulas and problems of output, things that could be fixed and easily controlled. But when they approached the market they immediately encountered an entirely different situation.

Markets involve the constantly changing whims and fancies of a fickle public, of such forces as obsolescence, the demand for style changes and many other expressions of a public psychology, none of which are either fixed or controllable.

Regulatory laws that control, for instance, every ton of steel that leaves the rolling mills either by building codes, specifications, standards, etc., are all subject to manipulation by organized competing interests. If unfavorable restrictions are incorporated, then costs are advanced and competition derives an economic advantage.

It is a long way from the plant to the market and yet if a business is to endure, it must sell at a profit what the plant can produce.

Executives have usually approved large appropriations for plant improvements, but when the call came for market development and for market research, the objective to them was too vague and too indefinite. Unlike machines, brick and mortar, the results could not always be measured. Appropriations for market promotion were too often refused or reduced to a point where they became ineffective.

And yet the fact remains that we cannot squeeze profits out of bricks and mortar!

Nothing more tangible could be referred to than the new markets advocated by the American Institute of Steel Construction. If fully developed they would supply an estimated 20,000,000 additional tons of steel for the rolling mills and for the structural steel industry. This represents a tonnage five times the present capacity of the entire fabricating industry. This market would develop from a plan of promotion executed on a cooperative basis.

In the field of welding we are experiencing changes and advancements that should call for an organization of interests and a practical cooperative program. The rapid development of weldng and its broad application presents problems of national importance that must be met if the industry is to maintain its economic position.

The training of operators, standard tests for inspection, research to expand the safety and practicability of welding are all essential factors that call for cooperative effort on the part of all the interests involved.

As an indication of the changes that are taking place, reference can be made to an old-established manufacturer of rivets who has added welding wire to his present line.

Recently the American Steel Foundry Company placed an order for welding equipment.

Machine bases of structural shapes and plates welded together are proving less costly, more durable and more attractive than those produced with castings.

The American Sheet & Tin Plate Company is constructing the largest cold rolling mill in the world at Gary, Indiana. Sheets will be rolled up to 84 in. in width. In the past, housings have been made of cast steel. If those required for the Gary mill were to follow this custom, a single housing would weigh over 250,000 lb. There are only two or three foundries in the country which could pour that much metal at once. There are none which could produce a larger casting. These housings for the Gary mill are to be made of welded rolled steel. There is no limit as to size when produced by this process.

Steel castings may and probably do contain internal defects which would prevent uniform results, yet the rolled steel is uniform throughout. The rolled steel housings can be shipped in sections and then assembled and welded together at any convenient point, whereas cast steel housings must be shipped as a single piece.

The use of rolled steel for the Gary mill netted a saving of $5000.

In the construction of the Boulder Dam it was found that welding was the only process by which the steel tunnel lining could be fabricated and assembled. It exceeds 30 ft. in diameter, and fifty thousand tons of steel plate, up to $2^7/_8$ in. thick, are required.

These instances demonstrate very clearly the inroads being made by welding into other competitive fields. To sustain its position and insure continued progress there must be organized cooperation, always alert to preserve the gains made and to achieve even a greater record of progress.

It should be obvious to all that the market now becomes the immediate problem. Its protection, development and promotion will become the responsibility of each industry. Cooperation among all competitors will be necessary if markets are to be created and protected so that outlets for each individual concern may be assured.

Promotional work conducted by any one company is effective when it supplements similar work pursued by a trade association. By itself, its effectiveness is reduced because of the selfish commercial interest that is involved and which is dissipated in the public mind when promoted by a trade association, for the association is a non-commercial institution with nothing to sell.

Such cooperation activity, aimed primarily at better merchandizing methods, offers the one assurance of prosperity. During this period of stress, the problem is to locate buyers to absorb what we produce, to make them want what we have for sale.

It has been our trade organizations, our conferences, conventions and meetings that have tended to increase the sum total of knowledge of their members. There have been too many who have been indifferent to the opportunities offered. We cannot escape the fact that the non-cooperator has been too busy with his own affairs to appraise properly the world or the community in which he lives. He has been too preoccupied to realize that the crisis facing his business today will require, before it is over, a more intimate cooperation, not alone by the leaders of his industry, but by the rank and file of all of its units.

If those who are not supporting their trade associations are to remain isolated and pray that some mysterious power will come to their rescue, then they will find that their prayers will never be answered. Any disintegration of trade associations would throw industry back to jungle days. These are times when any reliance placed upon individual effort would be about as effective as dropping a pin into the Grand Canyon.

The individual concern unaided cannot cope with this modern-day struggle for markets. The forces that are marshalled against it are too great. The battle line is too far flung. The vision to see that the individual concern can prosper only as the industry prospers, offers the sole hope of survival.

Trade associations must be strengthened and sup-

ported by larger memberships. They are in need of a greater moral and financial support. Most of them maintain efficient organizations and they should now be equipped for more aggressive action.

In considering the cost of membership it is well to remember that no one company could possibly afford to appropriate the amounts necessary to cover an aggressive campaign. But when the total cost is shared proportionately by all members of an industry then the individual contributions are greatly reduced.

Budgets are usually based upon an assessment levied against shipments. They are a direct item of cost included for sales promotion and as such they become a part of the cost system. All amounts are collected from the customer to be reinvested for his benefit and advancement. Under such an arrangement there are no hardships imposed upon any one and the public derives full benefits.

In this country it is essential, it is legally required, that all trade associations be voluntary. Membership is determined upon the individual decision of each unit. And no organizations can be greater or stronger than the members who respect them and give them their confidence.

Voluntary membership has given to trade associations a spirit, a complexion, that they would not otherwise have had. And it has limited the opportunities for good that might have been achieved sooner. If trade associations were recognized, licensed or sanctioned by the Government, there are many sociological functions that they might conveniently undertake to the good of the public that they do not now perform.

There is a new problem of membership that is now awaiting the attention of trade associations and, if permitted to pass unnoticed, it may develop into the most destructive of any that has so far been encountered.

An old-established concern in Texas became involved in the recent depression and was thrown into bankruptcy. A prominent bank appointed as receiver a man without any previous experience in that line of business. For years this company had only one important competitor within their city and they had always enjoyed cordial relations. The first act of the receiver was to resign as a member of their national trade association, to discontinue all relations with competitors and pursue a policy that removed all profit for competitors unless they offered cheaper foreign merchandise and indulged in demoralizing business ethics. As a result of such a program, this only competitor began to incur large losses, the first during the fifty years of their existence.

This is but one among many instances where banks are actually destroying solvent customers as they instruct their receivers to liquidate no matter what extremes may be necessary to do so.

The banks probably more than any other interest have failed to recognize what membership in trade associations means to improved credit standing.

The member of an association is the cooperator—the one who is exerting every effort to promote better business and to insure the profits.

The non-member is the non-cooperator who is trying to tear down all the constructive work being undertaken by his competitors. He invariably indulges in price cutting as a means of obtaining his business. He is actually scuttling the ship upon which he himself is afloat.

The non-member is not as good a credit risk as the member, yet most bankers draw no distinction. How can they justify such an attitude when trade association members are earnestly attempting to promote better conditions, thereby safeguarding credit, whereas by their refusal to cooperate, non-members lend encouragement to destructive business methods?

The time may come when banking institutions will be forced to recognize membership in a trade association as a mark of distinction. When that time does come business will advance another step in its struggle for profits and sound business principles.

I may repeat: if business men are unwilling to support their trade associations, to participate honestly in constructive programs for the advancement of their industry, then they alone must assume full responsibility if the government steps in and exerts a control over our business affairs. That is a possibility any sane man should strive to prevent.

But the handwriting is on the wall plainly visible to those who wish for guidance. There will be more radical legislation proposed in the new session of Congress than ever before. Business has been severely indicted and it must be prepared to stand trial.

The challenge to industry today is whether we are going to meet the issue and solve it effectively or whether we are going to invite the Government to do it for us.

The people of the United States have declared for a democracy and American industry is confronted with the serious necessity of proving that these economic emergencies can be successfully coped with under a democracy, that our business problems can be solved through cooperative effort and without recourse to governmental interference. This is certainly a time when we should all be willing to submerge our willful desires, our selfish ambitions for the betterment of our industries and thus prove our ability to cooperate for progress.

(*Continued from page 3*)

Effects of Welding Temperatures on Steel Gate Valves." Mr. Bartlett gave the actual results of a series of tests on welding flanged nipples to the ends of steel gate valves which were conducted by the Crane Company. His talk was illustrated by slides.

At a meeting of the Pittsburgh Section held on May 11th the following officers were re-elected for the 1933–1934 season:

Chairman, L. R. Gurley, Editor, *Welding*.

Vice-Chairman, F. M. Bernard, Westinghouse Elec. & Mfg. Co.

Secretary, J. F. Minnotte, Minnotte Bros. Co.

Section Representative on National Board of Directors, L. R. Gurley.

SAN FRANCISCO

One of the best attended meetings of this Section was held on April 21st at the Boeing School of Aeronautics. Dinner was served at 6:30 and at 7:30. Mr. T. Lee, Jr., General Manager of the Boeing School of Aeronautics, officially greeted those present. For the next hour Mr. A. F. Bonnalle, Dean of the Schools, arranged the showing of several interesting films under the direction of Mr. Walter Van Haitsma. Opportunity of seeing one of the large multi-motored planes of the United Air Lines leaving for Chicago, was next on the program.

The next meeting of this Section will be held on June 9th at 7:30 P.M. in the Auditorium of the Pacific Gas & Electric Co., San Francisco. The principal speaker of the evening will be Mr. H. H. Tracy, Engineer of the Southern California Edison Company, Los Angeles. Mr. Tracy will discuss "Design of Welded Buildings with Particular Reference to Seismic Shocks." The talk will be illustrated with slides.

Some Factors Governing the Choice of Welding Electrodes

By WAYNE A. HOWARD

✦Presented before the Los Angeles Section of the American Welding Society, Thursday, February 16, 1933. Mr. Howard is Testing Engineer, Consolidated Steel Corporation, L. A.

MANY details, concerning the methods of arc welding and of the quality of welds as produced by the various processes, have been discussed at these meetings but very little has been said regarding the actual procedure as followed by the users of welding equipment in selecting welding electrodes. In making such a choice the user is concerned with the problem of classifying the many electrodes now on the market as to their operating characteristics and as to the properties of welds resulting from each type or class, so far as the electrode influences these matters.

It has been found unsatisfactory to depend alone for our classification upon specifications limiting the chemical properties of welding wire because in this product, as in other metallic materials, the chemistry of the product does not entirely control the physical properties. The physical properties of a hard-drawn wire to be used for welding control, to a large extent, its operating characteristics. At present it is rather difficult to specify the structural make-up of a wire in satisfactory terms. The surface finish or materials applied to the surface in the nature of washes or coatings can completely alter the operating characteristics and the results obtained from the same wire in the uncoated condition. The purchaser of welding electrodes usually does not have a control over the wire structure or of the coatings applied to the wire and since he is confronted with such a large variety of brands and types the problem of making a correct selection for any particular application would seem rather complicated.

In an effort to get some help on the problem from the manufacturers of welding electrodes several of the representatives were questioned regarding the best method of proving to our own satisfaction that any particular choice would be a wise one. Invariably the suggestion was made that we do one or both of two things—assume that because other uses of welding wire have accepted any particular product as a standard, that it would be equally good for our use, or we have been asked to obtain a few samples and try the wire out under actual operating conditions. A trial usually consists of having one of our welders burn off a few sticks of the wire, make certain observations and have the welder give his opinion of its quality. I think we are all familiar with the results of this method of testing welding wire. If the opinon of the welder and other conditions at the moment happen to be in favor of the wire, everything is lovely. If the opinion and the conditions appear to be adverse to the rod, we are then immediately informed that the welder was prejudiced, that the current and voltage values were wrong, that the arc manipulation was faulty, that we used the wrong size wire or encountered a stiff blow, or even that our welding generators were hay-wire and antiquated. As a matter of fact the representative may be absolutely right in all his statements, but even if he is he has failed to convince the purchaser that he has anything of any value to offer.

This procedure is mentioned only to illustrate conditions that sometimes exist and often prevent the proper choice of welding electrodes and is not said to discourage the efforts of the trade in presenting new products. Possibly these remarks will incite a discussion regarding the betterment of the methods of tests used at present.

I wish that I could tell this group exactly how to select the proper welding electrode for every type or condition of welding, but I will have to admit that all I can do is suggest some factors governing this selection that may be pertinent to the question.

Welding electrodes may be said to differ from one another in four major items:

1. Their size and shape.
2. The analysis of the metal of which they are composed.
3. The method of forming or drawing or other manufacturing treatment influencing the wire structure.
4. The wash, coating or covering that is often applied over the metal to impart certain desirable operating characteristics to the electrode.

The first of these differences is relatively unimportant and can be considered a matter of convenience. Drawn electrodes are round and cast electrodes are square and their length has been standardized somewhat for convenience in packing and using.

The second variable, that of the metal itself, deserves considerably more attention. It has been a general practice for a number of years to select electrodes, the metal of which would analyze similar to the metal to be welded. This has been a good rule to follow in the majority of cases, but we depart from this practice when welding cast-iron by using a bronze electrode, or very often a welding electrode having a higher carbon content than the steel to be welded is used to counteract the fact that carbon is lost to the deposit by the excessive heat of the arc. In one series of tests it was found that 44% of the carbon, 16% of the manganese, 1% of sulphur and 6% of phosphorus were lost to the weld deposit from the average value of these elements contained in both the electrode and the plate material. This test was made on uncoated electrodes. Other investigations indicated that in the case of coated electrodes practically no carbon or manganese was lost to the deposit. Mr. J. C. Hodge of the Babcock & Wilcox Company, in a recent article in the JOURNAL OF THE AMERICAN WELDING SOCIETY, gave some figures that were a little more startling than those just presented. He states that in the case of the bare arc weld 88% of the carbon is lost, 16% of the manganese and that a gain of 2100% in nitrogen was observed. In the case of coated electrodes 31% of the carbon was lost, 14% of the manganese and a gain of 260% in nitrogen was observed. He stated that in the case of coated electrodes the average gain of nitrogen in the deposit over that usually present in structural steel is 300% or more. These figures, of course, as all others of this nature, derived from a certain series of tests under controlled conditions.

We might find in these figures a hint as to how to select our electrodes as to chemical composition, that is, it might be possible to purchase welding electrodes of such analyses as to allow us to finish with an exact desired chemical composition in the deposited metal. The characteristics that are desired in the weld, of course, must also be known—is the weld to be of high strength,

very ductile, machinable, corrosion-resisting, of stainless material or is it to resist abrasion? With these factors at hand and the figures just presented from Mr. Hodge's paper, we can perhaps select with some confidence the desired chemial composition of the electrode.

It is important to study the metallurgy of the electric arc weld when selecting electrodes for special welding. For instance it should be known that the loss of zinc by vaporization prevents a solid and homogeneous weld in brass and bronze by the use of the electric arc; that welds made with high carbon electrodes are very apt to be brittle along the line of fusion; that the ductility in high manganese deposits can be retained by quenching the weld while it is still red hot. Other equally important considerations are present in the welding of stainless alloys, all involving factors not to be overlooked.

We are quite certain that the wire to be used for welding electrodes should be of a uniform high quality. Each batch of wires should be as nearly as possible identical in all its properties with any other batch. Uniformity of a product governs, to a considerable extent, the choice of electrodes by trade names. Welding wire hard drawn to a tensile strength of 100,000 lb. per sq. in. and with an elongation in 2 in. of 5% is about that which is desired. The grain structure undoubtedly has something to do with the characteristics of the action of a welding wire in the arc especially in the case of bare-arc welding, and some investigators have tried to correlate the X-ray defraction pattern of the wire structure with its operation in the arc. These considerations are highly technical at present and do not seem to offer any immediate assistance to the layman to help him make a correct selection of wire structure.

The items just mentioned concerning the material and method of manufacture of welding electrodes concern coated electrodes as well as the uncoated variety. In reality every welding electrode has some type of coating on it. The so-called bare-wire electrode has often a light surface finish consisting of lime or of a drawing compound, or very often a patented wash. These coatings undoubtedly help in breaking up the globules of metal on the end of electrodes into smaller particles so that the metal is transferred from the electrode to the work with higher efficiency. Such washes are valuable and have a definite stabilizing effect upon the arc. With the event of the heavy coated or covered electrode, we are not only concerned with the selection of the wire itself, but with the coating material. There are certain desirable characteristics that we expect to obtain from these coatings that may make it possible to set up tentative standards for coatings. Some of these items are as follows:

The coating or covering must be placed about the welding wire in a uniform manner. A high rate of deposit without porosity is desired. We are not particularly concerned with the amount of coating a manufacturer puts on his wire, if it accomplishes the purpose intended without interfering with the arc. The coating, however, should burn at about the same speed as the wire, perhaps a trifle slower so that a more perfect shielding of the arc itself is accomplished. A deep crater on the end of the electrode generally means that a greater current density can be used with less heat loss and that a more fluid metal can be obtained. The coating when being burned must be absolutely free from fumes injurious to health of the operator or to his eyes, such as the fumes from lead or zinc oxides. Large volumes of smoke, even though it be harmless, are objectionable for obvious reasons. Technically the coating must be of such a nature as to provide a protection for the metal while it is being deposited and is preferably a slag-forming coating that protects the hot metal while it is cooling. This slag, of course, must have the correct viscosity and melting point to impart the correct surface tension to the molten metal to avoid trapping slag in the weld to allow the metal to build a bead, and to prevent troublesome undercutting along its edges. It is desirable that the slag be easy to remove and that the resulting weld have a pleasing surface appearance. Embrittlement often found in a bare-arc weld is due to a large extent to nitrogen and oxygen being dissolved in the deposited material. Therefore, a coating that can form a gas active in the absorption of nitrogen and oxygen is of great value. The average coating falls far short of these ideals.

To a rather limited extent it has been our experience that extruded coatings are superior to dipped coatings and that coatings composed of organic materials, or a mixture of organic and mineral materials, are superior to coatings composed entirely of pulverized minerals. Perhaps this point will come up for discussion later and we may possibly find a reason for this.

The advantages of a coated electrode over a bare electrode need not be mentioned. However, it is interesting to note that most investigators have found a surprisingly small difference between the cost of welding with bare and covered wire, the additional cost of coating being nearly offset by the gain in welding speed. The improved properties derived from the use of the coated electrode are, therefore, obtained with slight, if any, additional expense. A recently published article concerning the practice followed by the U. S. Navy stated that coated electrodes are used only on down hand welding, and that bare electrodes are used on vertical and overhead welding. This fact may not be true universally throughout the Navy and is certainly not true in civil practice as a large amount of vertical and overhead welding has been successfully accomplished with coated electrodes, using a smaller amount of coating as a rule than that usually present on the down hand wire and in nearly all cases welding wires $^{3}/_{16}$ in. in diameter and smaller. Bare-wire welding is still used extensively in automatic work where facilities have not been provided or developed for shielding the arc, but in my opinion bare-arc welding is rapidly becoming obsolete.

After we have set up these more or less arbitrary factors governing the wire and its coating, we are still deeply concerned with the method of testing electrodes to determine if these theoretical considerations are correct and to determine which electrode is the most ideal for any particular application. Since so many variables may enter into a test of this nature, it would seem that the only satisfactory test could be obtained by employing some automatic device for feeding the electrode at a constant rate and maintaining a constant arc voltage. A device of this kind enables us to make a thoroughly dependable and reliable test or comparison of the various electrodes, as many variables present in the welding circuit—and affecting the stability of the arc—become known constants when automatic equipment is used. To obtain complete information on one electrode it would probably be necessary to weld a test coupon consisting of two plates properly beveled, at least $^{5}/_{8}$ in. in thickness, 18 in. to 24 in. in length and 9 in. in width. The items that can be observed while the weld is in progress when bare electrodes of a mild steel composition are used, are as follows:

The welding current; the welding voltage; the rate of melt-off in inches per minute, the amount of splatter and vapor loss; the distance welded in inches and the welding speed in inches per minute.

The suggested minimum values for items obtained by testing the completed bare-arc weld, are as follows:

Tensile strength—50,000 lb./sq. in.
Yield point—40,000 lb./sq. in.
Elongation in 2 in.—10%
Charpy impact value—2 to 15 ft.-lb.
Density—7.60
Fatigue limit—18,000 lb./sq. in.
Reduction of area—20%
Ductility by the free bend test—10%

When coated electrodes are used, the following additional items should be observed:

Operation of the arc; amount of slag; ease of slag removal; position of the slag in the crater; appearance of the crater and appearance of the finished weld.

The suggested minimum numerical values of the items obtained by testing the completed shielded arc weld are somewhat different from those given for bare electrodes and are as follows:

Tensile strength—60,000 lb./sq. in.
Yield point—45,000 lb./sq. in.
Elongation in 2 in.—30%
Charpy impact value—25 ft.-lb.
Density—7.80
Fatigue limit—30,000 lb./sq. in.
Reduction of area—50%
Ductility by the free bend test—30%

and the porosity, by the nick-break test, to meet A. S. M. E. code allowances. After these observations have been made, a work value of the electrode may be determined by assigning weighted values to each of the above items. The weighted values assigned, of course, will differ for each investigator depending upon the purpose of his test. This work value, when divided by the price per pound of the welding wire, gives a factor of merit which should govern the selection.

Where the corrosion resistance of the weld metal is important, it is suggested that coupons be selected from the specimen welded and given a corrosion test. This test consists of immersing the specimen in a 1% normal solution of hydrochloric acid in cycles of one minute in the air and one minute in the acid. The minimum loss of tensile strength on such specimen should average not more than 30% after 7 days in this test. If a specimen consisting entirely of weld metal is used, the loss of weight of the specimen in a given period of time would be the unit of measuring the results of corrosion.

Splatter loss or the efficiency of deposition can be determined by measuring the total amount of welding wire consumed in pounds and by weighing the specimen plate before and after welding. Of course all products of splatter must be removed after welding before the plates are weighed.

When coated electrodes are used the weight of the coating must be subtracted from that of the total weight to obtain the weight of metal. Coatings usually weigh about 15% of the total weight of the rods. Splatter losses have been found to be from between 6% and 22%, depending upon the current, plate thickness and upon the electrode. I have been told that this is probably a conservative figure but only a small amount of information on this factor is available from which reliable average figures can be obtained.

There is a possibility of comparing the efficiency and uniformity of electrodes by using a melting coefficient. The unit is grams-per-ampere-minute. This, of course, could apply best to bare electrodes. Desirable electrodes possess a coefficient of between 12 and 18 grams-per-ampere-minute.

In suggesting a test by the use of an automatic machine, such as the one outlined, I do not mean to infer that hand-testing of electrodes is entirely without value; in fact, hand-testing is perhaps the only way we can determine the value of electrodes for overhead and vertical work, but it is believed that factors tending toward the uniformity of selection, and the factors which pertain most to the quality of the work at hand, can only be determined entirely satisfactorily by a control of the factors in a better manner than that provided by hand-testing.

A good suggestion, when it is necessary to choose an electrode without resorting to a test including the factors mentioned, was given to me in a talk with one of the welding wire representatives who is present here tonight. His suggestion was that a welding electrode should not show any unusual characteristics when in the hands of a competent operator. I wonder if I could have misunderstood what he said.

To summarize the factors governing the choice of welding electrodes, they can again be enumerated, as follows:

The chemical analysis of the material in the electrode probably serves as our best method of classifying them as to type; the structural composition of the hard-drawn wire in so far as we are able to determine its composition by the melting-off rate and arc characteristics further classify electrodes as to the uniformity of manufacturing procedure and finally the coating or covering that imparts desirable characteristics to the action of the electrode in the arc and to the properties of the deposited metal as determined by observations and physical tests of specimens welded. These factors, as suggested, are then broken up into additional individual units that may be assigned numerical values, the total of which determines the factor of merit upon which we may base our selection.

I sincerely hope that this paper has aroused your interest to a point where a frank discussion of the subject will take place before it is again allowed to lapse into a state of being an unmentionable proposition.

Discussion of Paper by Mr. Frank B. Walker on "Visual Inspection of Metal Arc Welds"

By ANTHONY S. COOMBS

†Mr. Coombs is connected with The Whitney Engineering Company, Boston, Mass.

THE paper by Mr. Walker* on "Visual Inspection of Metal Arc Welds" is very timely. Arc welding is coming into a constantly increasing use as a tool in the structural field. The engineer who employs this method must assure himself that the weld-

* JOURNAL OF THE AMERICAN WELDING SOCIETY, April 1933.

ing for which he is responsible is properly and safely done. Mr. Walker in his paper points out the characteristics of good and bad welds, and a careful examination of the welded specimens at the Society rooms should be of interest to all engineers.

At the present time, visual examination is the most practical method of inspecting welds used in ordinary structural work. Other methods involving more or less apparatus are being developed, and may in the near future come into more extended use. But with intelligent visual inspection the suitability of welds for load-carrying capacity may be promptly determined.

Not only should inspection cover the completed welds, but it should begin before the first production weld is made; that is, preliminary tests of all prospective welders should be required, in order to insure that the welders employed have the ability to produce work of the proper quality. These tests may be simply lap welds, to be broken and examined for quality or, for more important work, may include specimens for laboratory testing.

An experienced inspector who is on the work while welding is in progress will use his ears as well as his eyes. A short arc properly held gives off a characteristic steady crackling sound, easily recognized. A good workman will maintain this arc for the available length of his electrode, within the limits of the weld. If he has a tendency to let the electrode stick, it is indicated by the interruption of the arc. Too long an arc, also, has its characteristic sound, more of a hiss, interrupted with occasional popping sounds as globules of unfused metal are deposited.

The selection of an inspector involves considerable responsibility, and a very desirable qualification for inspection work is actual welding experience. If the inspector is a qualified welder himself, so much the better, but he should at least have had some welding experience. Such an inspector will more readily recognize and detect defects in technique that might tend to impair the quality of the weld.

The writer agrees with Mr. Walker that good welds will be made with proper procedure and when completed may be recognized as such by intelligent visual inspection.

Structural Changes at Stress-Relieving Temperatures

By **H. R. BULLOCK**

✦Report presented to Fundamental Research Committee, A. B. W., Annual Meeting, April 28, 1933, by H. R. Bullock, Assistant Instructor in Mechanical Engineering, Massachusetts Institute of Technology.

SLOWLY cooled low-carbon steels do not undergo any structural changes below the critical temperature. After quenching from above the critical, however, they are capable of marked structural changes and modification of physical properties upon reheating to temperatures below the lower critical. Although welded joints are usually thought of as being slowly cooled and, as such, capable of no structural modification below the critical, they are actually cooled very rapidly because of the high heat capacity of the parent metal. This quenching action is particularly true in arc welding where the heat is highly localized and the mass of deposited metal is small.

In the so-called multiple bead welding, the heat of successive layers of deposited metal causes recrystallization of previously deposited metal. In other words, the dendritic structure of the metal "as welded" has been broken down and reformed, usually as a sorbitic pearlite by reheating and cooling from above the A_3 line. With such a structure no change will take place on reheating below the critical. In other words, the structure of the *deposited* metal will be unaffected by reheating below the A_1 line.

In the fusion zone, however, we may expect a different state of affairs. Here we find plate metal and weld metal side by side, the plate structure nearest the weld modified by the welding heat and but a short distance away entirely unaffected. In this area plate metal is heated above the critical and rapidly cooled. This means that owing to the heat of welding the pearlite in the plate goes into solution with the ferrite immediately surrounding it but, owing to the short time that the high temperature is maintained, the amount of diffusion is relatively small. Greatest diffusion naturally takes place near the weld metal and immediately adjacent to the weld; where the plate metal has been carried to a very high temperature, complete diffusion should take place. Farther out in the plate, diffusion becomes less and less until a point is reached where the temperature has dropped below the critical.

Under the A_3 but above the A_1 temperature we would expect to find diffusion limited to an area immediately around the pearlite. These are the structures which we might expect to modify by a low temperature heating.

The plate metal nearest the weld, having already been completely diffused and rapidly cooled, will be affected by reheating in the same way that any quenched steel is affected by reheating. Plate metal a short distance from the weld will have been heated to slightly below the A_3 temperature and will be characterized by small dark areas. These areas show the extent of the solution and diffusion of carbides into austenite. The short time of maintaining the temperature prevents the structure from reaching uniformity over the entire area. The rapid cooling has the effect of a quench, the austenitic areas becoming troostite. These troostite areas will be modified by treatment at low temperatures as shown by photomicrographs.

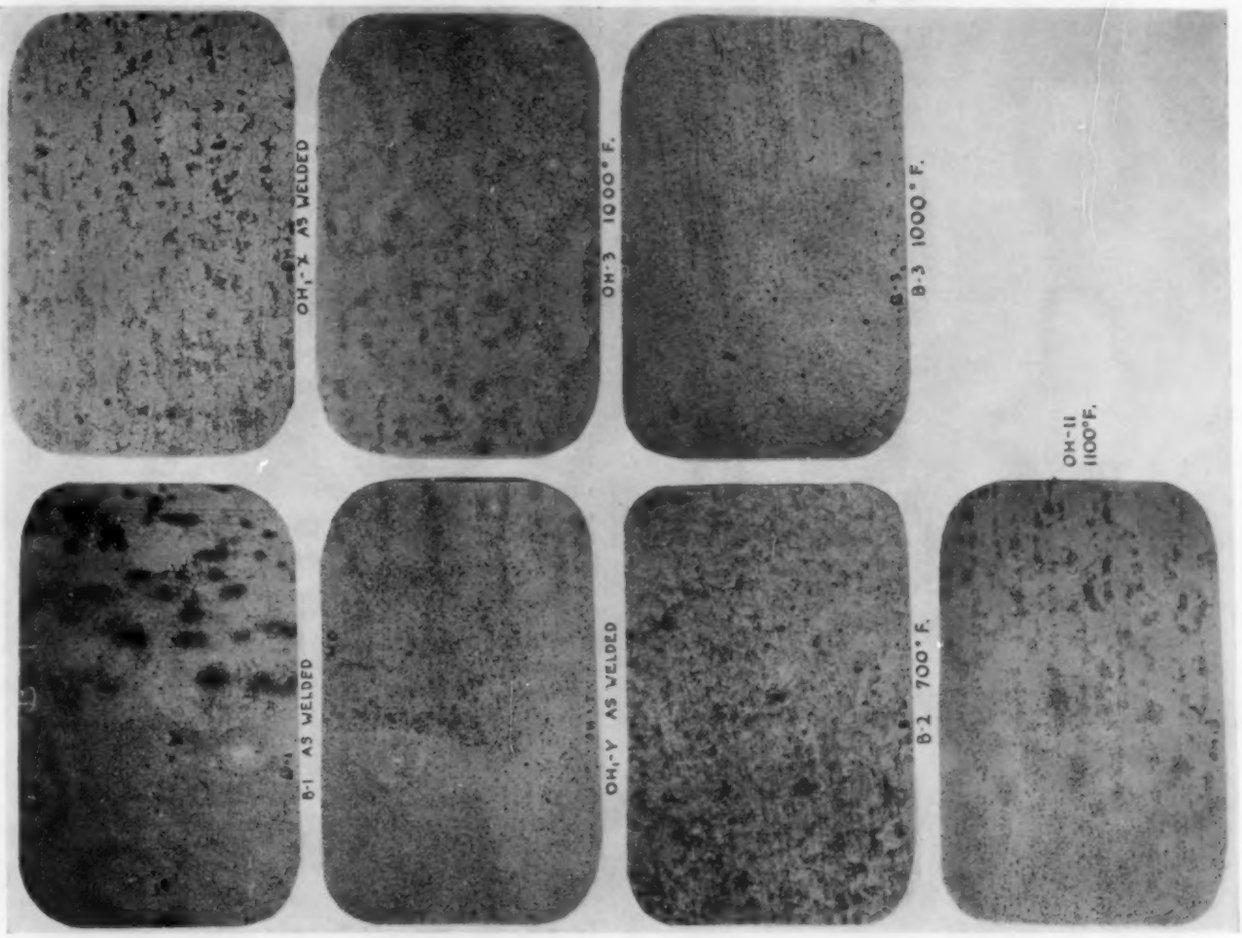
Structural changes on reheating would occur up to the point where the plate had been heated to the A_1 temperature by the welding heat. Beyond that point diffusion of pearlite would not have begun and normal plate structure would be observed.

The change in physical properties caused by these structural changes have not, as yet, been investigated. However, that definite and important physical changes do accompany such modification seems unquestionable. Properties such as hardness, tensile strength, ductility and fatigue resistance depend entirely upon structures. For that reason this limited study of structural changes indicates the desirability of further investigations.

Specimen B-1 shows the fusion zone of a multiple bead weld in which the heating effect of successive layers has started perceptible diffusion of the pearlite in the original plate structure.

Specimen OH_1X brings out this change more clearly, showing only the diffused structure in the original plate a short distance from weld.

OH_1Y shows the fusion zone of the same weld shown in OH_1X. In this case a greater amount of heat from



the welding has resulted in complete diffusion of the original structure.

All three specimens, so far considered, were in the "as welded" condition.

The structure in OH_1X after heating to 1000° F. is shown in OH_3. This temperature has caused the formation of a very coarse sorbite.

B-2 shows the dispersion occurring in specimen B-1 when it is heated to 700° F. Further modification of this structure is shown in B-3.

Specimen OH-11 shows the zone between the area of maximum visible dispersion and the nearly unaffected plate metal (specimen heated to 1100° F.).

The author would like to thank the Lincoln Electric Co. and the Metal and Thermit Corp. for the equipment and supplies used in this work.

SAFETY KINKS

Safe Handling of Oxygen and Acetylene Cylinders

By **T. C. FETHERSTON**

✦Mr. Fetherston is Manager, Technical Publicity Department, of The Linde Air Products Co.

OUT of the many hundreds of thousands of oxygen and acetylene cylinders in common service today it is remarkable what a negligible percentage is ever found to be defective in the hands of users. This is in part the result of the rigid specifications to which these cylinders are made and to the regulations of the Interstate Commerce Commission and the Bureau of Explosives under which they are used. However, the most important factor contributing in this direction is the unremitting vigilance of every responsible manufacturer and distributor of these gases, each of whom leaves no possibility unexplored for making his equipment thoroughly efficient and dependable.

Occasionally, however, usually because of damage in transit, a cylinder of one gas or another will be received by the customer in a leaking condition.

In the case of oxygen cylinders so received, they should be placed out of doors in a position where the escaping oxygen will not come in contact with flammable material of any kind or even with hot metal, and the gas allowed simply to escape. The manufacturer should be notified and whatever action he indicates should be taken. Usually this simply involves returning the empty cylinder to his plant or warehouse for an appropriate adjustment.

Wrenches should not be used in an attempt to tighten up the oxygen valve nor should any effort be made to take the valve apart and adjust or repack it. Valves

on oxygen cylinders are especially designed and built to withstand and control the high pressure carried in such cylinders and they cannot be repaired properly except with a full knowledge of their specific characteristics and a complete set of special tools and replacement parts.

If an acetylene cylinder should be found to be leaking around the valve stem this condition can often be remedied by tightening up the packing gland nut. Always use soapy water in testing for leaks in acetylene connections; never use a match or an open flame of any kind. If this does not completely stop the leak, or if the leak is in a safety plug, the cylinder should be moved out of doors and the acetylene allowed to escape freely into the atmosphere. It should, of course, not be placed near any flammable material or where the acetylene-air mixture might come in contact with flame, fire, sparks or hot metal, or where the escaping acetylene can collect in any type of closed or semi-vented container. Of course, the manufacturer should be notified promptly and his instructions as to the disposal of the cylinder followed. In practically all cases this instruction will involve allowing the gas to escape completely, closing the valve as tightly as possible by hand and returning the cylinder to his charging plant.

Spherical Tank Built by Arc Welding

By **A. F. DAVIS**

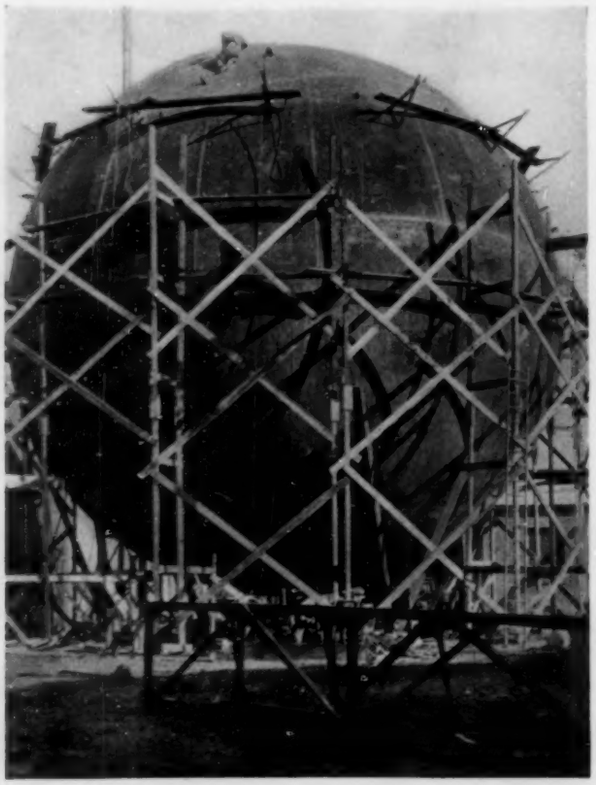
✦Mr Davis is Vice-President of the The Lincoln Electric Company, Cleveland, Ohio.

A NEW type of mixing tank for gas, the first of its kind, has recently been completed for the St. Louis County Gas Company at Shrewsbury, Missouri. This tank, which is spherical in shape, is known as the Hortonsphere. It is 45 ft. in diameter and has a rated capacity of 162,000 cu. ft. of gas at 50 lb. per sq. in. working pressure. This installation was fabricated and arc welded in the field by the Chicago Bridge & Iron Works. The shell plates were dished and the edges prepared in the shop. The plates were then match marked and shipped to the field for erection.

A derrick was used to assemble the structure in the field. The plates were hoisted into position and tack welded. The welders then went over all the seams, using four beads on each joint. Each bead was thoroughly cleaned and peened before depositing the succeeding bead.

There is a total of approximately 1256 lin. ft. of seam on a Hortonsphere of this size or a total of 5024 ft. of welding. Each welding operator was assigned a definite portion of the work and required to mark his welding with a special stamp.

The welding was completed in approximately fourteen days. All welding was done by the shielded arc process. The tank was given a soap suds test at 70-lb. air pressure. No leaks were discovered. This type of construction is particularly advantageous for gas storage as it practically eliminates the possibility of leaks in the joints.



Cromansil Steels

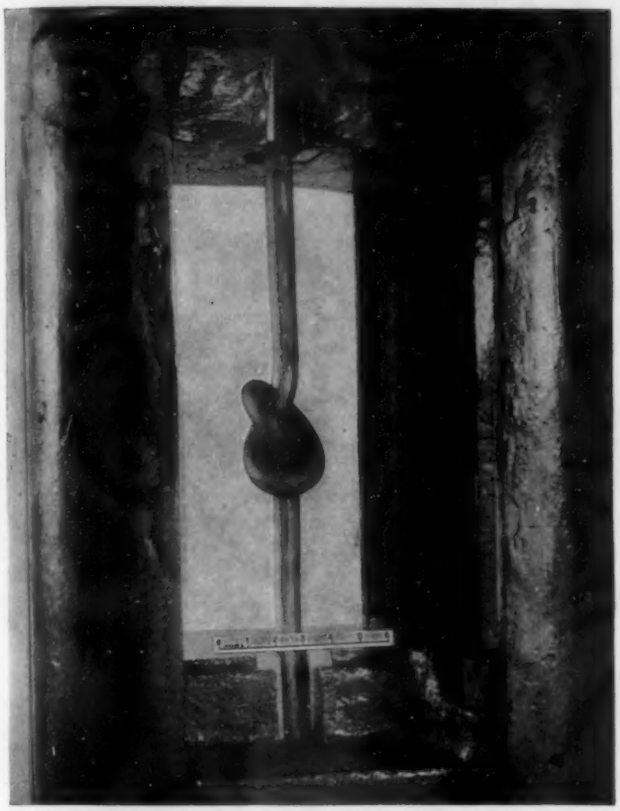
By **RICHARD TULL**

✦Mr. Tull is on the staff of the Technical Publicity Dept., Electro Metallurgical Company.

High-Strength, Low-Alloy Steels for Structural Purposes

A CRYING need for several years has been an economical high-strength, low-alloy steel that could be readily adapted to the varying needs of structural engineers. One of the factors retarding the use of alloy steels for these purposes has been the necessity for heat treating the steels otherwise suitable, in order to develop the desired physical properties. To overcome this difficulty, several attempts have been made, with more or less success, to improve the physical properties of structural steels by the addition of small quantities of alloying elements. The silicon structural steels and the silicon-manganese steels are outgrowths of this study.

Further investigations led to the knowledge that small additions of chromium to silicon-manganese steel greatly improve the desirable physical properties. As a result, a series of low-alloy steels known as cromansil steels have been developed for structural and engineering purposes. The term "cromansil" is used to indicate all steels within the recommended range of alloy content and does not designate any one particular alloy steel.



Here's One for the Sailors to Try. Cromansil Steel 1-In. Diameter Bar Stock

The range of composition of cromansil steels is comparatively broad and depends largely upon the uses to which they are to be put. These grades most widely employed at the present time contain from 0.4 to 0.6 per cent chromium, 1.1 to 1.4 per cent manganese and 0.7 to 0.9 per cent silicon, with the carbon content varying from less than 0.10 to 0.65 per cent.

In the as-rolled condition steel with this combination of alloys has better physical properties and higher strengths than any type of plain carbon steel. Strengths as high as 140,000 lb. per sq. in. in the as-rolled condition are obtainable and, by means of suitable heat treatment, these can be raised to 170,000 lb. per sq. in. In addition, high fatigue limit, great ductility and high impact strength can be obtained in the as-rolled condition. A fatigue limit as high as 60 per cent of the ultimate strength can be procured. This characteristic is of considerable importance in steels used for structural purposes.

Cromansil steels are easily manufactured by the open-hearth process. They can be readily rolled into standard structural shapes and can be machined, drilled, punched, sheared, cut by the oxyacetylene process, pierced and drawn, welded and otherwise fabricated without any essential variation from any standard manufacturing practices.

Since it is possible to use cromansil steels in the as-rolled condition, many applications suggest themselves which ordinarily could not be considered as suitable for the economic use of alloy steels. Ship plates and naval structural parts must be strong, yet their weight is a factor of paramount importance. Cromansil steel will furnish the desired strength and at the same time will decrease the weight of a section because its strength-weight ratio is very much higher than that of plain carbon steel, and at the same time it is tougher and more ductile. Similarly its use in bridges and buildings, pressure vessels, penstocks, etc., will be of decided advantage. The inherent qualities of great toughness and ductility have led to the extensive use of these steels for seamless tubing. Over 2,000,000 ft. of cromansil steel oil-well casing has been used with the most satisfactory results. The results obtained in a number of applications show that cromansil steels will help solve a great many of the problems confronting structural engineers. A high-strength low-alloy steel that can be used in the as-rolled condition has always been in great demand, and cromansil steels satisfy this need.

Standard Specifications for Resistance Welding Transformers

Prepared by **RESISTANCE WELDER MANUFACTURERS ASSOCIATION**

1. The term, "Resistance Welding Transformer," shall apply to the heating transformer used in any and all types of resistance welding machines, such as butt welders, flash welders, spot welders, projection welders, roll seam welders, fabric welders, pipe seam welders, chain welders, ring welders, etc., and shall apply to welders built for welding copper, brass, aluminum and other non-ferrous metals, as well as steel and iron and shall apply to machines both power operated and manually operated.

2. Duty Cycle.—The rating of resistance welding transformers shall be based on a duty cycle of 50%. It is understood, of course, that the service on the transformer is much more severe for the same ampere load where the duty cycle recurs rapidly, this service becoming more severe as the number of cycles per minute that the current is on and off increases. However, to overcome the heating from a high duty cycle such as is the case with fast operating spot welders, it will be necessary for sales engineers to specify a larger transformer where the duty cycle is high than would be required and specified for a lower duty cycle, even though the ampere load may be the same. In order, however, that a basis may be established for a standard design of resistance welding transformer, the rating shall be based entirely upon a 50% duty service.

3. Name-plate Rating.—The name-plate rating of resistance welding transformers shall be expressed in kv-a. and shall be marked with the following data: primary voltage and frequency, primary amperes and kv-a., together with the type and serial number of the welder and the following inscription: "Above rating is in accordance with standards adopted by the Resistance Welder Manufacturers Association."

4. Primary Windings.—The primary windings shall be wound of high conductivity copper wire, cold drawn and annealed, preferably of rectangular section with rounded edges. The cross-sectional area will be based on 1800 amp. per sq. in. cross section. In order to use the nearest commercial size wire it may be desirable to use a wire of somewhat different size than the exact dimensions required, but in no case shall a wire other than the nearest commercial size be used.

5. Secondaries.—The secondaries shall be designed with a section as nearly uniform as possible and shall be

made from high conductivity material such as rolled copper, cast copper or cast aluminum. If cast material is used, it should be properly water cooled. (No cast copper shall be used that has a conductivity less than 80% and no cast aluminum shall be used that has a conductivity of less than 40%.) The cross-sectional area of secondaries shall be based on 2000 amp. per sq. in. of rolled copper. With a variation of 5% either way, this area shall be divided by 0.8 if cast copper is used and by 0.4 if cast aluminum is used to determine the cross section of the secondary, and used direct if rolled copper is used. The contact surfaces where electrical connections are made to secondaries shall be at least four (4) times the cross-sectional area of the secondary.

6. Taps.—All taps shall be connected to the primary windings in a manner which will give the required mechanical strength as well as maintaining the full carrying capacity of the wire.

7. Cooling.—All cast secondaries that are to be water cooled shall be provided with tubes cast in, or holes drilled in, arranged so as to give the proper distribution of cooling.

8. Insulation.—Primary coils wound of bare copper strip shall be insulated between turns with inorganic material such as mica or asbestos in built up form combined with binding substances. There shall be at least 0.030 in. total thickness of insulation.

Coils wound of D. C. C. wire shall be insulated between layers with varnished cambric or its equivalent.

9. Core.—The iron core shall be built up from not thicker than 24-gage high-grade electric sheets, cleanly cut to proper shape and built up so that each sheet overlaps the joint in the under layer by at least one inch, except when butt joints are made in the core. The magnetic density shall not be more than 70,000 lines per sq. in. on 60 cycle transformers and not more than 85,000 lines per sq. in. on 25 cycle transformers, except in the case of cores built up with a butt joint where the density should not be more than 90% of standard core densities. Proper core clamps shall be provided so that the laminated core and the coils are held rigidly in place.

10. Inspection and Test.—Every transformer shall be properly inspected before assembling in the welder frame. After the transformer is assembled in the frame, transformer test shall be made and a record of core loss and ratio kept on file. Break-down voltage tests should be made between primary winding to ground, secondary to ground and primary to secondary with potential at least twice the operating voltage.

11. Mechanical Protection.—All welder transformers must be protected from flying particles of metal from the weld, by properly placed barriers, also must be protected from oil, water, dust or dirt and must be guarded to insure the safety of the operator.

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